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THE RELATIONS

OF MIND AND BRAIN

> Ἐμοὶ μὲν γὰρ οὐ φαίνεται, ὃ ἂν χρηστὸν ᾖ σώμα, τοῦτο τῇ αὐτοῦ ἀρετῇ ψυχὴν ἀγαθὴν ποιεῖν, ἀλλὰ τοὐναντίον ψυχὴ ἀγαθὴ τῇ αὐτῆς ἀρετῇ σῶμα παρέχειν ὡς οἷόν τε βέλτιστον.
>
> Plato, *Repub.* iii. 403.

THE RELATIONS

OF

MIND AND BRAIN

BY

HENRY CALDERWOOD, LL.D.
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THIRD EDITION

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PREFACE TO THIRD EDITION.

FOR the present Edition the discussion on "Animal Intelligence" has been carefully revised. The closing part of the chapter on this subject has been entirely re-written. Deliberate account has been made of the most recent observations, including those on the "Language of Animals," and the discussion on "Animal Ethics" in the treatise on "Justice" by Mr. Herbert Spencer.

Extended observations on HYPNOTISM have thrown additional light on the relations of Mind to bodily sensibility and movement. On this account I have been led to inquire how far fresh inductions have become possible from the great array of facts supplied by enlarged medical experience. High value attaches to what has been lately done by the School of Nancy, and by other observers, specially in Paris and in Berlin, assigning a prominent place to "Suggestion," in causation of nerve-sleep, as well as subsequently in

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direction of the sleeper's activity. The subject seems one of so much importance, theoretically and practically, that I have added an Appendix to the present edition, giving a full discussion of the nature of the Hypnotic sleep, and of the testimony regarding the relations of mind to body afforded by Hypnotic phenomena. The data have been so carefully verified as to be now widely acknowledged by scientific observers, including many medical practitioners.

H. C.

UNIVERSITY OF EDINBURGH,
January 13, 1892.

PREFACE TO THE SECOND EDITION.

THE demand for a second edition came so much earlier than had been expected, that it found me unprepared to meet it. For the delay which has thus occurred in publication I have now to express regret.

The work could not, I was persuaded, be regarded as complete, without a thorough study of "Animal Intelligence;" whereas continued research and reflection had greatly deepened my sense of the perplexities of the subject.

Gradually I became satisfied that our studies in Neurology were being to some extent misdirected by too exclusive attention to comparative Brain structure. This led on to the conclusion, now emphasised in this edition, that the primary requisite for successful research is to compare the entire Nerve System of the several animals, and not merely the Brain, or even the combination of Nerve Centres, belonging to them. As the Sensory System (aided always in functional activity by the Motor) is the recognised instrument of discrimination, it naturally follows that comparative development of Sensory Apparatus must be taken as a leading feature along with Cerebral development. From this position a considerable number of existing perplexities are seen to be modified in a marked degree. The intelligence of the ant, the dog, the horse, and the ape, is presented in a different light; and the results are such as appear to call for some modification of the Theory of Evolution, in so far as it is concerned with the relation of evolution of Organism to evolution of Intelligence. Without venturing to claim that a complete theory of "Animal Intelligence" has been here worked out, I submit the outlines of a theory which appears to me to come nearer a true induction than comparative neurology has hitherto reached.

Besides the addition of the new chapter on "Animal Intelligence," consideration has been given to recent research and discussion in other branches of the subject; and, besides this, the many valuable criticisms of the first edition of this work which had appeared in scientific journals have been carefully pondered.

I have to express my sense of the kindness shown by recognised authorities in Neurology, when noticing a first venture into a most difficult region of research by one whose main studies have been devoted to the very different region of Mental Philosophy.

By my colleagues connected with the Medical Faculty I have been laid under fresh obligations. To Professor Turner, LL.D., I have been largely indebted, and also to Professor J. Cossar Ewart, M.D., since he entered on the duties of the Chair of Natural History. The drawings supplied by Professor Ewart of the antenna and leg of the ant are a valuable contribution to the work, and will, with other figures introduced into this edition, afford important help towards estimating the argument now submitted.

H. C.

UNIVERSITY OF EDINBURGH,
November 10, 1883.

PREFACE TO THE FIRST EDITION.

The object of the present work is to ascertain what theory of mental life is warranted on strictly scientific evidence.

The order followed is to consider, *first*, the latest results of anatomical and physiological research as to the structure and functions of the brain; *second*, the facts in human life unaccounted for by anatomical and physiological science, and requiring to be assigned to a higher nature.

On the side of Mental Philosophy, it must be recognised that analysis of consciousness cannot be regarded as affording a complete survey of the facts of personal life. On the other hand, it is clear that the known facts connected with cerebral action do not include familiar phases of mental activity. If we allow ourselves to be engrossed with Physiological investigations as to brain, we restrict our attention to a single class of facts, and become unable to take a view of human life as a totality. The whole range of evidence must be traversed, if we are to secure a harmonious representation of the constitution of human nature.

The acknowledgments I have to make for friendly assistance during the long-continued and difficult investigations involved are many. Great generosity on the part of my colleagues has given me full advantage of the facilities for inquiry which the University affords. I have to record my special gratitude to Professor Turner, of the Chair of Anatomy, who has been untiring in his friendly assistance; to Professor Rutherford, of the Chair of Physiology; to Professor Crum Brown, of the Chair of Chemistry; to Professor Grainger Stewart, of the Chair of Practice of Medicine; and to Dr. Clouston, Lecturer on Mental Diseases in the University.

I have also to express my particular thanks to Dr. James A. Sidey for revision of the proof-sheets, and to the Rev. Alexander Mair, D.D., for revision of selected portions of the work. Valuable aid has also been afforded me by Dr. Dodds, Assistant to the Professor of Physiology; and by Mr. Stirling, Assistant to the Professor of Anatomy, and Assistant Curator of the Anatomical Museum.

Readers will understand that no one of the friends named is in the least degree committed to the positions here maintained.

Thanks are also due to many authors and friends who have kindly replied to inquiries addressed to them.

Large use of Illustrations prepared for standard works in Anatomy and Physiology has been generously afforded me. Acknowledgment of these favours is made as the illustrations are introduced.

H. C.

UNIVERSITY OF EDINBURGH,
26*th April* 1879.

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THE RELATIONS OF MIND AND BRAIN.

CHAPTER I.

RELATIONS OF PHILOSOPHY AND SCIENCE.

PHILOSOPHY and Science are so related as to constitute a unity. The one is concerned with the facts and problems of rational life; the other with the facts and problems of material existence, animate and inanimate. They are at one in seeking a rational explanation of observed facts. They adopt the same method, depending upon observation, analysis, classification, and reasoning. However widely separated the regions of inquiry, searchers for truth are working in harmony, whether they recognise the fact or dispute it. Each group is a body of specialists, but the results of inquiry, wherever prosecuted, bear upon one grand problem concerning the universe. It is recognised equally by Philosophy and Science, that things existing constitute a system, or organised order of existence. It is granted, therefore, that careful research, whatever direction it take, must result in some contribution to the grand total of human knowledge. And it is equally clear that those most entitled to a hearing on any branch of inquiry are those who have devoted themselves to research in the department with which that inquiry is concerned. Only thus can real advance be made on the vast region of research which the universe presents. Philosophy must wait on Science, and Science in turn wait on Philosophy.

Here, as most readily occurs to one devoted to the study of the phenomena of mind, it needs to be insisted upon, that the inquirers themselves belong to the universe about which they inquire. And it should be clear—even a truism—that the inquirers present the grandest elements in the whole problem. For, to study, and to unfold even partially, the system of things existing, is to prove superiority in the midst of the system. It is to prove that there is reason in all things. And if so, the rational nature, which can unlock the secrets of the universe, most of all deserves attention.

From such elementary considerations, it is plain that all science is in a radical sense philosophy, and all philosophy science. It may even seem a needless distinction to speak of one form of inquiry as scientific, and of another as philosophic: making one set of generalised results a science, another set a philosophy. Usage has, however, established the practice. And it is convenient to have the distinction. The sciences have come to be regarded as concerned with some department of the physical universe, in contrast with what pertains to the nature and laws of mind. This distinction has been held with sufficient definiteness for all practical purposes. Yet, science is so obviously a philosophy, that the old terminology was warranted which distinguished a Natural Philosophy from a Mental Philosophy,—a philosophy of nature from a philosophy of mind. On exactly the same ground we may speak of philosophy as a science. Scientific knowledge, the higher knowledge gathered by recognised scientific methods, cannot be restricted to certain spheres. Wherever observation is possible, and reflection as to the laws which regulate recognised facts, science is possible. If there may be a science of the formation of bone, muscle, and nerve, leading to the recognition of laws which operate in some manner quite beyond our experience, so may there be a science of perception, association, and inference, leading to the recognition of laws applicable to the facts of our experience. Man himself belongs to nature. The science of human life, in the full breadth of meaning belonging to the word "life" in this connection, has its place among the natural sciences. Physiology and Psychology when taken together are sciences of human life; they cannot be dissociated. Only when they are combined can we be said to have a science of the life of man. The claim is therefore a reasonable one, that the whole nature of man be included within the scope of natural science. I am far from thinking that external observation alone will prove sufficient to guide us to a science of human life. But internal observation proceeds upon the same conditions, and is as entitled to confidence as external. By the blending of the two a science of human life may be reached, which will certainly be unattainable if either form of observation be exclusively employed.

Not unfrequently "scientific methods" have been claimed as belonging to the physical sciences alone. Mental philosophy, as treated in the works of well-known psychologists, has been ridiculed as if it had proceeded in disregard of "scientific methods." The Scotch school of Philosophy has been specially reproached on this ground. The fallacy of such a charge is glaring. Psychologists may not have given as much attention to physiological facts as they should have done, but to charge them on that account with constructing their theories in disregard of observation is obviously unwarrantable. Those who would fasten upon psychologists of former days such a charge as this, must be prepared to maintain that thought and recollection and volition are not facts, or that these are facts which do not occur according to law, or that both facts and laws are beyond the reach of scientific inquiry. There is no one who will hazard his reputation on the attempt to vindicate any one of these alternatives. The old psychologists most certainly did not proceed in neglect of the laws of observation and inference. And though there may be better reason for urging that physiology has been too much neglected by metaphysicians, the charge is often unreasonably pressed. You might as well charge the old physiologists with having neglected to use anæsthetics in the vivisection employed in the study of the nerve system, as charge the old psychologists with neglecting the full use of physiology. The real state of the case is simply this—that physiology has never up till this time been in a position to give sufficient testimony as to the functions of nerve and brain to throw much light on philosophic problems. Even now the physiology of nerve and brain is far from being in the advanced position which it must occupy before it can contribute towards the answer of many pressing questions concerned with mental action. Only quite recently have we had systematic investigation as to the possibility of localising functions in definite regions of the brain. And even yet there are very serious disputes as to what the results of accredited observations may involve. In these circumstances it hardly seems warrantable to charge against psychologists neglect of the teaching of physiology as bearing on the action of mind.

That psychologists have hitherto adopted an unreliable method of investigation cannot be maintained. If observation of facts, analysis for the discovery of distinct elements, classification of things similar, and inference resting on wide induction, are enumerated among "scientific methods," psychologists have regularly employed them all. By these methods they have come to very general agreement as to the rational and emotional nature belonging to our race. It has no doubt been said [1] that there is "no agreement" among those who resort to internal observation; but every one who is familiar with the works of psychologists knows that the statement is inaccurate. As to the laws of observation, of association, of reasoning, of pleasurable feeling, there is all but perfect agreement among them.

It is, indeed, the fact that psychologists have trusted to their own consciousness, that is, to their own experience, in seeking to ascertain the laws of mental life, and some physiologists tell us that consciousness is not trustworthy. It has even been said that "there is no witness who is so easily suborned to give false evidence as self-consciousness." [2] But this is an assertion on which there is not agreement among physiologists, nor is it clear that evidence in its support can be gathered by use of scientific methods. It were indeed strange were any science to offer itself as defender of the dogma,—that man is not to trust his own experience. What may he trust if not this? Take the most ordinary and commonplace tests. How but by consciousness does any man know that the blue appearance of his hands on a wintry morning is the accompaniment of coldness, or that perspiration is attendant on a high degree of heat? When a man says that he feels warm, is it a sad misfortune that "he appeals to a witness whose evidence can be taken by no one but himself"? Is it true that this is a witness "whose veracity cannot be tested"? To throw doubt upon experience

[1] Maudsley's *Physiology of Mind*, 3d ed., p. 16.

[2] *Ibid.* p. 17.

is to deny the possibility of knowledge, and so of all science. When the psychologist trusts his consciousness he simply does what every man does,—what every man must do, who is not insane. Trust in consciousness is no speciality of psychologists, but the common prerogative of humanity. Here there can be no rational conflict between science and philosophy. Physiology must refer to consciousness in order to carry through its own investigations. A physiology of the senses must take account of the facts of consciousness connected with sight and hearing. Any scientific handling of the problem of localisation of functions in the brain is impossible without giving careful attention to the facts of individual consciousness. Of the host of physiologists now engaged on this question, I am not aware of one who does not make habitual reference to the consciousness of others, besides placing constant reliance on his own.

There seems to me but one sphere in which we find ourselves on debatable ground, that is, when we consider the case of the insane. And it surely throws no discredit on consciousness, but is rather a testimony to its trustworthiness, if we encounter difficulties as to its testimony only when we come to deal with what is abnormal in life. But even here there are only complications, as the result of disturbance from an abnormal physical condition. If we disentangle these complications, we shall find that the trustworthiness of consciousness is confirmed. In our asylums for the insane, administration does not proceed on the assumption that the consciousness of the patients is not reliable. There is not a physician in any one of these Asylums who does not found his diagnosis on the assumption of the reliability of his patient's consciousness. Even where there is the most extraordinary hallucination, the physician does not treat his patient as a cheat who is playing off tricks on the medical officers. On the contrary, he distinguishes between attempted deception and real hallucination. In regarding the hallucination as fact, he takes the consciousness of the deluded person as a reliable witness, and proceeds to consider what may be the source of the acknowledged hallucination. On this basis the physician prescribes, and he is vindicated in the assumption on which he proceeds by the number of cures he effects. On this same admission are based the rational methods of treatment, now accepted as the only methods which can pass for scientific. All the prescriptions and forms of discipline familiar in asylums for the insane are used in accordance with observation, and that is based not only on what the physician sees, but also on what the patient says.

There is still another phase of exaggerated criticism of psychological investigations into which some physiologists have allowed themselves to be drawn. I refer to the objection taken against introspection, or observation of the facts of our own consciousness. To object to this is to object to our observing, recording, and comparing the facts of our own experience, in order to ascertain the conditions of our own life. The objection is futile, as it is confuted by every man who employs it. If we would know what is within, how shall we be satisfied but by looking within? Impossible, says an acute physiologist; the thing cannot be done;—if you turn attention on the current of thoughts and feelings passing within, you disturb the current, nay, even break it, and so lose the thing for which you are seeking.[1] This much Dr. Maudsley has borrowed from Comte, and to small advantage. Every man is conscious of his thoughts and feelings, that is, he knows them as elements in his own experience. The physician does not hesitate to ask his patient how he feels. He does not apologise for the question, as if it hazarded a sudden termination of all experience save sudden perplexity. Every one possesses the ability to describe his own experience, and is well aware that it is possible to concentrate attention on a definite class of facts in his experience, without seriously disturbing the current of his thoughts and attendant feelings. If there is to be any regard to the facts of personal experience,—and all physiologists admit that attention must be given to them,—it is impossible save by reference to consciousness, and such reference involves introspection.

On the other hand, it is impossible to construct an adequate philosophy of mind by use of introspection alone. Experience does not carry its own explanation. There is very much essentially connected with our experience, which nevertheless does not come within experience. We must, therefore, turn observation in other directions. And he who grants the validity of observation when turned upon the inner sphere, will no less freely grant its value when turned upon the outer.

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[1] Maudsley's *Physiology of Mind*, p. 17.

If, notwithstanding what has been said, it still be maintained that mental philosophy has not in this respect honoured physiology as it should have done, I do not dispute that there is ground for the charge. But it should be remembered that the departments of inquiry are so distinct, that each must wait upon the other for the materials with which to institute comparisons. Physiology must complete its own work for purely physiological ends before psychology can be in a position to deal with the relations of the two provinces. We must first know with accuracy what are the functions of physical organs before we can advance to the further question how far personal experience is involved in their fulfilment. Psychology allows that harmony of physical and mental action is certain, inasmuch as these two forms of action belong to the unity of life. And what psychology undertakes to do is, to formulate its own assertions concerning the relations of mind and body, in view of the verified results of physiological research. Psychology justly expects physiology to do as much in dealing with the verified results of introspection.

Physiology is not even yet in a position to present a sufficiently exact account of the several functions of nerve and brain. Most able and devoted students of the science admit that it is still premature to advance such a claim on its behalf. But there is now a large body of ascertained fact calling for some deliberate attempt to harmonise results with the facts of mental experience. And psychologists have even the deeper, because more direct and pressing, interest, in attempting to ascertain how far a harmony between the two departments of inquiry can be reached.

There are, indeed, some physiologists who easily and summarily cast aside the question. They simply assert that it is vain to seek for harmony, inasmuch as there are not two sides to harmonise. With them physiology is everything, psychology nothing. They deny the reality of mind as a distinct order of existence, associated with body, but of a superior nature. They allege that there is no evidence in human life of the existence of any power or force which cannot be traced to physical organism. The exercises commonly called "mental are only higher and finer forms of nerve action. Nerve force is the highest order of force operating in human history.

Here, then, we come upon the foundation question for all mental philosophy. The present condition of physiological and psychological research requires that this question be carefully considered. Current theories concerning the origin and development of life on the earth, and speculation affecting the order and government of the universe as a whole, have more or less bearing on the question, and lend additional interest to it. Besides, it is impossible to overlook the fact,—and it is important to note it,—that researches into comparative anatomy and physiology are leading in many cases to a statement of the problem itself which virtually assumes that brain is the measure of what is highest in human life. I take but a single example from one who is recognised as a careful observer and an acute reasoner. Referring to Bischoff's statement, that the brain of man and the brain of the orang do not perfectly agree at any period of their development, Mr. Darwin says, "Nor could this be expected, for otherwise their mental powers would have been the same."[1] Thus, so early as the first chapter of his work, it seems to be assumed by Mr. Darwin that brain power and mind power are to be identified; or, at least, that the one is the exact measure of the other. And this is done when the comparison of human brains involves great perplexity for such a view; and when, besides, it is clear that there is not a little nerve action which involves no mental power. When the fact of *reflex action* was demonstrated, it was clearly established that nerve action does not in itself imply mental action. Whatever may be involved in a comparison of brain powers, the problem before us cannot be simply identified with the question of resemblance of structure. Our problem is in one way something narrower than this: and, in another aspect, it is much wider. For there is not a little nerve action which is not connected with "mental phenomena;" and there are many forms of nerve action which carry us quite beyond the physiology of brain and nerve for their explanation. And yet in almost all treatises on the nerve system there is now and again a tendency to resort to forms of expression which unintentionally seem to imply that these two problems are identical. And this, I think, arises from a constant comparison of the analogies and homologies of brain structure in different orders of beings, while too little attention has been turned on specialities of brain recognised in different animals. A certain homology of brain structure up the whole scale of animal life will be freely admitted as scientifically established. In accordance with this homology, however, the brain of man is recognised as beyond all dispute at the head of the scale; yet it is assuredly within the scale of animal life, for no one doubts that man possesses an animal nature, though most will refuse to admit that he is nothing more than an animal. But, after the homology of brain structure is admitted as a fact in the economy of animal life, the comparison of the different powers possessed by living beings, and exercised by them in connection with brain action, such, for example, as sight and hearing, remains as a distinct problem.

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[1] *Descent of Man*, vol. i. p. 11.

In proceeding to deal with this problem, I prefer to approach it by the path which physical science has opened. Granting that the brain is the organ of the mind (" das Seelenorgan," as Rudolph Wagner has named it), the problem may be stated thus,—Given a physiology of brain and nerve, to ascertain whether this constitutes a philosophy of the phenomena commonly recognised as " mental phenomena." These phenomena may be summarised under the three words, Thought, Emotion, Volition, taking all these terms in their commonly received meanings. I shall attempt first a summary of the results of anatomical and physiological research, and afterwards consider how far these results carry us in the interpretation of the facts of our own life.

CHAPTER II.

STRUCTURE OF THE BRAIN.

THE object of the present treatise leads me to concentrate attention on the nerve system, upon which the sensibility and activity of the body depend, whatever more may be included among its functions. Though intimately connected with the whole body, it can be studied and described without necessity for a prior detailed account of all that belongs to the structure and functions of bone and muscle.

The nerve system may be contemplated from two distinct points of view. We may begin with the periphery or external extremities of the system, where there is contact with the outer world. From those minutest fibres, which are most remote from the centre, we may trace the strands upwards, reaching the connecting points where several strands combine, and so continue until we find them converging on the spinal cord, and thence passing up into the great nerve centre, the Brain itself. Or, we may take our stand-point at the centre of the system in the brain, contemplating the great mass there accumulated, and also in the spinal cord, from both of which nerve fibres issue; and thereafter we may observe the manifold ramifications, breaking forth in all directions to penetrate the entire muscular system and organs of sense. The latter is the preferable stand-point for those who seek to obtain a view of the system as a whole. This is obvious, for in looking from the centre outwards, completeness of view is maintained; whereas, looking from the periphery inwards, we are forced to take a variety of positions, each one giving only a limited view of the system. For this reason I take the brain as the starting-point for description.

Underneath the solid, hard covering of the cranium, and enveloped within three membranes, is the brain proper, or cerebrum. Below this, and to the rear, are grouped three important though smaller and subordinate subdivisions of the great central mass, the cerebellum, or little brain; the pons or bridge; and the medulla oblongata, or elongated mass in direct relation with the upper part of the spinal cord. These four taken together constitute the great nerve centre, the brain proper being the most important by far, not only larger, but much more complicated in structure. When in the following description I use the name "Brain," I intend only the cerebrum or brain proper—the large organ filling the main cavity of the skull. In anatomical and physiological works the name is not unfrequently applied to the whole central bodies taken together, all that is within the head, hence named Encephalon.

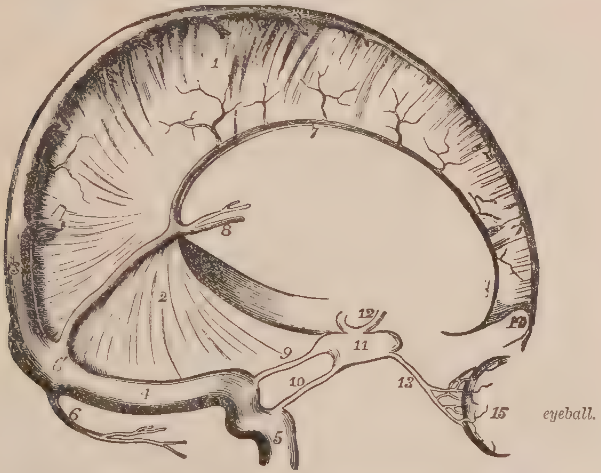

FIG. 1.—THE TOUGH OUTER COVERING OF THE BRAIN.
(*From* Professor Turner's *Anatomy.*)

"Dura mater and cranial sinuses. 1, Falx cerebri; 2, tentorium; 3, 3, superior longitudinal sinus; 4, lateral sinus; 5, internal jugular vein; 6, occipital sinus; 6′, torcular Herophili; 7, inferior longitudinal sinus; 8, veins of Galen; 9 and 10, superior and inferior petrosal sinuses; 11, cavernous sinus; 12, circular sinus, which connects the two cavernous sinuses together; 13, ophthalmic vein, from 15, the eyeball; 14, crista galli of ethmoid bone."

Of the three membranes which cover the brain, the outermost (*dura mater*) is the toughest and strongest. From this tough covering strong bands, as the falx and tentorium, pass between different parts of the encephalon. In this membrane are also situated the channels or blood sinuses which convey the venous blood from the brain. Below this tough covering is the intermediate membrane (*arachnoid mater*), a much more delicate structure, stretching round the whole brain, but without descending into the various inequalities which are presented over its surface. Between the outermost and intermediate covering there is a supply of serum, moistening the inner surface of the tougher covering, and the upper surface of the more delicate membrane. Below this second covering is a third membrane (*pia mater*), which not only encompasses the whole, as the others do, but keeping close to the surface of the brain, descends into the various furrows, and conveys blood-vessels into its substance. These three coverings enclose the spinal cord, as they enclose the brain.

Within this threefold covering lies the brain, a large soft mass, in two halves or hemispheres, of a reddish grey tint, arranged in folds or convolutions which have a definite position and direction. By means of these convolutions there is a large exposed surface within the narrow limits which the skull affords, the soft mass being arranged alternately in ridges, and in grooves or furrows (*sulci*).

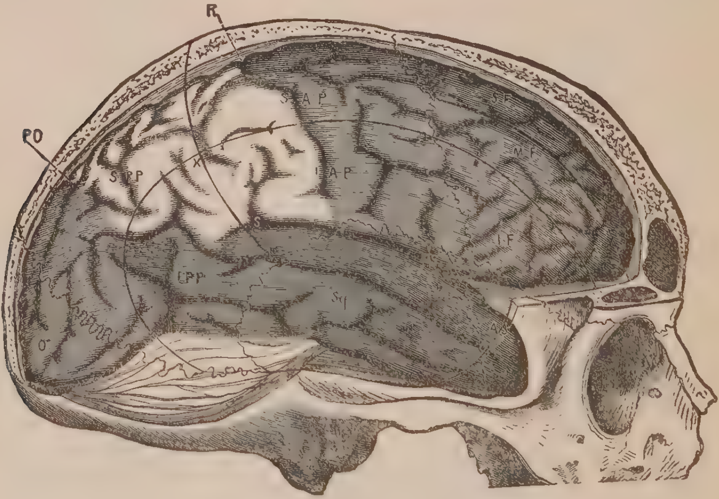

Fig. 2.—THE BRAIN AS SEEN IN POSITION WITHIN THE SKULL.
(*From* Turner's *Anatomy.*)

"The above view of the brain *in situ* shows the relations of the surface convolutions to the regions of the skull. R, fissure of Rolando, which separates the frontal from the parietal lobe. PO, parieto-occipital fissure between the parietal and occipital lobes. SS, fissure of Sylvius, which separates the temporo-sphenoidal from the frontal and parietal lobes. The frontal area lies in front of the coronal suture. SF, MF, IF, the supero-, mid-, and infero-frontal subdivisions of the frontal area of the skull; the letters are placed on the superior, middle, and inferior frontal convolutions; the inferior frontal region is separated from the middle frontal by the frontal part of the curved line of the temporal ridge; the mid- from the supero-frontal by a line drawn backwards from the upper margin of the orbit through the frontal eminence. SAP, the supero-antero-parietal area of the skull; S is placed on the ascending parietal convolution, AP on the ascending frontal convolution. IAP, the infero-antero-parietal area of the skull; I is placed on the ascending parietal, AP on the ascending frontal convolution. SPP, the supero-postero-parietal area of the skull; the letters are placed on the angular convolution. IPP, the infero-postero-parietal area of the skull; the letters are placed on the mid-temporo-sphenoidal convolution; the temporal ridge separates the supero- and infero-parietal regions from each other; a vertical line drawn from the squamous to the sagittal suture through the parietal eminence separates the antero- and postero-parietal regions. X, the convolution of the parietal eminence, or supra-marginal gyrus. O, the occipital area of the skull lies below the lambdoidal suture; the letter is placed on the mid-occipital convolution. Sq, the squamoso-temporal region of the skull; the letters are placed on the mid-temporo-sphenoidal convolution. AS, the ali-sphenoid region of the skull; the letters are placed on the tip of the supero-temporo-sphenoidal convolution. The black lines mark the boundaries of the different cranial areas."

This soft convoluted mass grows with the growth of the head in early life, but attains to its full size at a comparatively early period. There is diversity of opinion as to the time when the full magnitude is reached. Most authorities place it not later than the eighth year.[1] This may fairly point to the period at which formal instruction should begin, while education in the deeper sense in reality begins with the earliest attempts at discrimination between the feelings and actions of others.

While, however, the maximum size of the brain is reached thus early in life, there is thereafter a steady increase in *weight*. This increase goes on with marked advance till about twenty years of age, and thereafter by slower stages till about forty years of age. Beyond this period, according to observations made on a pretty wide scale, there seems to be a slow diminution, which may be stated at about one ounce in ten years. Thus in very advanced years the brain is considerably lighter than in middle life.

From tables which have been constructed on data afforded by a large number of cases (taking together the four divisions —brain proper, little brain, bridge, and medulla), it appears that the ordinary weight of the European brain is from 46 to 52 ounces. In a considerable number of cases the weight falls below the lowest figure named; in a considerable number, it rises above the highest figure given. As scientific inquiry has been directed largely on a comparison of the human brain with the brain of the ape, it may be well here to give a few examples of the weight of brain among the higher apes. Professor Owen gives two cases of the chimpanzee, the one weighing $9\frac{3}{4}$ ounces, the other $13\frac{1}{4}$ ounces; Marshall weighed one brain, which, with its membranes, reached 15 ounces. Professor Rolleston had the brain of an orang weighed, and it was 12 ounces.[1] Bischoff estimates the mean brain weight of the adult male gorilla at about 442 grammes (about $15\frac{1}{2}$ ounces).[2]

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[1] Opinions vary from three years to eight, but the preponderating view points to the seventh year. See Quain's *Anatomy*, 8th ed., vol. ii. p. 578.

In the case of man, the weight of the brain proper, of which I am chiefly to treat, may be seen by taking an example of the whole four divisions of the nerve centre at 50 ounces. Giving the comparison in ounces, it may be stated thus:—the brain proper, 44; the little brain (cerebellum), 5; and the other two parts, 1. This gives a much greater proportion to the brain

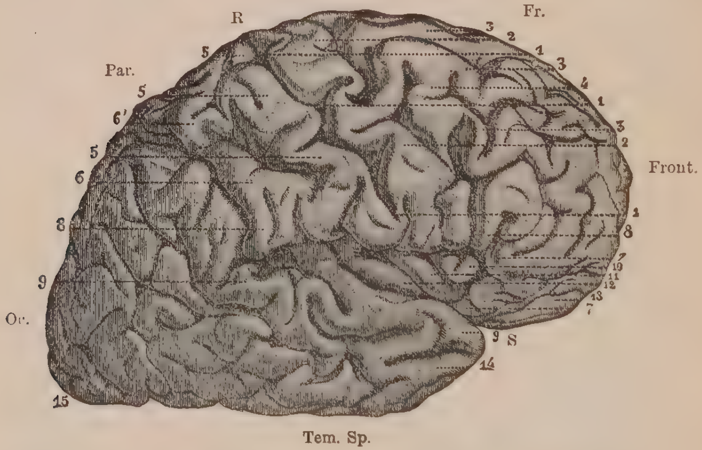

Fig. 3.—VIEW OF THE RIGHT SIDE OF THE HUMAN BRAIN $\frac{1}{2}$ (Foville).

(*From* Quain's *Anatomy.*)

"1, fissure of Rolando; 2, anterior ascending parietal convolution; 3, frontal convolutions connected posteriorly with the anterior ascending parietal; 4, union of two frontal convolutions; 5, posterior ascending parietal convolution; 6, another parietal convolution similarly connected with those on the inner surface; 7, 7, anterior part of the convolution of the fissure of Sylvius; 8, 8, horizontal part of the same convolution; 9, 9, posterior part; 10, 11, 12, anterior, middle, and posterior principal convolutions of the island of Reil or central lobe; 13, supraorbital convolution; 14, part of the temporal lobe; 15, occipital lobe."

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[1] *Natural History Review*, 1861.

[2] *Sitz. der math.-phys. Classe*, Munich, March 10, 1877.

proper in man, as compared with the cerebellum, than is usual in the lower forms of mammals.[1]

If next we consider the relative weight of the entire encephalon to the weight of the whole body, we have a summary of results in the tables of Clendinning, Tiedemann, and Reid.—(Quain's *Anatomy*, vol. ii. p. 580.) From these authorities it appears that the average weight of the brain proper and subordinate divisions of the nerve-centre in relation to the body is as 1 to 36; or, in cases where there has been no diminution of muscular strength prior to death, 1 to 40. In cases of full muscular development the proportion is smaller than in cases where bodily strength has been reduced under the influence of disease.

I come now to speak more particularly of the general configuration and structure of the brain proper. I begin with the side view of the organ, taking the right hemisphere for the example.

Looking at fig. 3, it will be seen that the extent of surface is greatest across the central part, and that the height is much greater in the front region than at the back. Running the eye along the margin from front to back, it is seen that the front rises clear up with a curve, which is well represented by the appearance of the forehead, while the rear falls greatly away, as by a rapid descent from the main elevation.

Within this mass there are clearly marked subdivisions. Amongst the numerous convolutions there are two deep fissures, which constitute natural boundaries for separate portions of the organ. Most conspicuous to the eye is that which opens into the mass from the base at a point distant from the front about one-third of the whole extent. This is the Fissure of Sylvius, or the Sylvian Fissure. It begins at S, at number 9 on the right. With a slightly upward tendency at first, it runs towards the rear, terminating about the point touched by the dotted line coming from the number 9 on the left side of the figure. This fissure may be said to divide the middle portion of the brain into an upper and an under region, leaving the whole of the front part undivided from base to summit. This fissure is the first to appear in the development of the brain of the fœtus, and thus beyond doubt it is an essentially important dividing furrow.

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[1] See Dr. J. Reid's Table as given in Quain's *Anatomy*, vol. ii. p. 581. Also Reference Tables arranged by Mr. Barlow, in Professor M'Kendrick's *Outlines of Physiology*, p. 713.

Looking now along the top of the mass, and a little towards the rear, a fissure of considerable breadth and depth, the Fissure of Rolando is seen appearing at R, taking a course which decidedly tends downwards and forwards towards the frontal region. Its course is indicated by the figures 1, 1, 1.

By these two fissures there is division of the brain proper, first into higher and lower, and, second, into front and rear. The latter division applies to the upper portion of the brain lying above the Sylvian fissure. Towards the back part of the brain, slightly visible on the outer surface, is the Parieto-occipital fissure, which indicates a twofold subdivision of the upper portion of the brain behind the fissure of Rolando. The front of the brain, as far back as the fissure of Rolando, is known as the Frontal Lobe; behind the Frontal, as far down as the Sylvian fissure, and as far back as just a little below the figure 8, is the upper central division, known as the Parietal Lobe; behind that is the Occipital Lobe; in advance of this, on the lower part, and below the Sylvian fissure, is that known as the Temporal Lobe, or Temporo-Sphenoidal. These four lobes are the four divisions of the superficial area, in both hemispheres. Besides these four, however, there is another concealed from view, hid under the folds of the Sylvian fissure, constituting a Central Lobe, which, on account of its insulated position, is known as the Island (*Insula*), and is distinguished by the name of its discoverer, the Island of Reil. In figure 3, the island is shown by the lines running from 10, 11, and 12, marking the three convolutions, which together constitute the Central Lobe.[1] The reader must therefore imagine the fold just above these convolutions drawn down so as to cover them entirely, and the front portion of the brain proportionately lowered. Thus drawn down, the fold will meet the under fold of the Sylvian fissure running up from S. When these three convolutions are thus covered, the natural appearance of the left hemisphere is obtained. (See fig. 5, p. 18.) This five-fold arrangement of the lobes is that of Gratiolet, and is now generally accepted.[1]

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[1] The Island or Central Lobe is that which appears first in the growth of the brain, so that the rest are grouped round it. Yet it is represented as peculiar to man and the higher apes. It has been made the subject of special investigation by Dr. H. C. Major.—*Lancet*, July 14 and 21, 1877.

From the view of the profile of the brain proper, it is needful to pass to another, obtained by looking down upon the mass from above. From this point of observation there comes into view

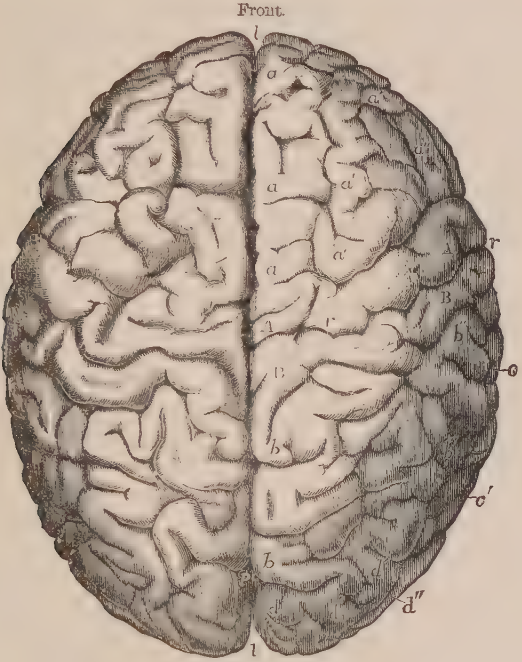

FIG 4.—UPPER SURFACE OF THE BRAIN. ½

(*From* Quain's *Anatomy*, after R. Wagner.)

"This view was taken from the brain of a famous mathematician, Professor C. F. Gauss, who died in 1854, aged 78. It is selected as an example of a well-formed brain of the full size with fully developed convolutions.

a, superior or first frontal convolution; *a′*, second or middle frontal; *a″*, third or inferior frontal; A, A, ascending frontal convolution; B, B, ascending parietal convolution; *b*, first or upper parietal convolution; *b′*, second or middle; *b″*, third or inferior; *c*, first or upper temporal convolution; *d*, first or upper occipital convolution; *d′*, second or middle; *d″*, third or lower; *l*, *l*, the superior longitudinal fissure; *r*, the fissure of Rolando; *p*, parieto-occipital fissure."

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[1] Quain's *Anatomy*, vol. ii. p. 523; Turner's *Anatomy*, vol. i. p. 267.

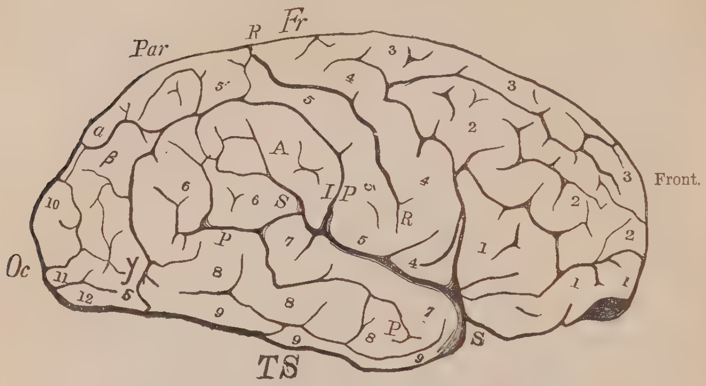

Fig. 5.—RIGHT SIDE OF THE HUMAN BRAIN, DRAWN IN OUTLINE.
(*From* Turner's *Anatomy.*)

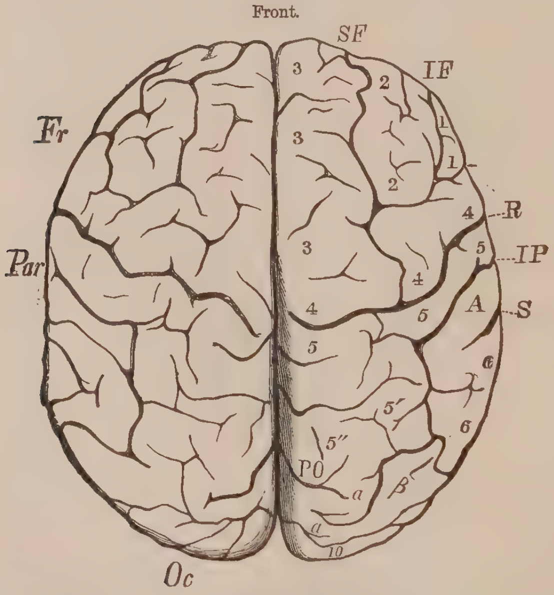

Fig. 6.—UPPER SURFACE OF THE BRAIN, DRAWN IN OUTLINE.
(*From* Turner's *Anatomy.*)

"Profile and vertex views of Cerebrum. *Fr*, the frontal lobe; *Par*, parietal; *Oc*, occipital; *TS*, temporo-sphenoidal lobe; *SS*, Sylvian fissure; RR, fissure of Rolando; PO, parieto-occipital fissure; IP, intra-parietal fissure; PP, Parallel fissure; SF and IF, supero- and infero-frontal fissures; 1, 1, 1, inferior, 2, 2, 2, middle, and 3, 3, 3, superior frontal convolutions; 4, 4, ascending frontal convolution; 5, 5, 5, ascending parietal, 5′, postero-parietal, and 6, 6, angular convolutions; A, supra-marginal, or convolution of the parietal eminence; 7, 7, superior, 8, 8, 8, middle, and 9, 9, 9, inferior temporo-sphenoidal convolutions; 10, superior, 11, middle, and 12, inferior occipital convolutions; *a*, *β*, *γ*, *δ*, four annectent convolutions."

the double structure of the organ, by separation into two hemispheres. A straight line of separation, known as the great longitudinal fissure, runs along the summit, making a division of the brain into two perfectly distinct halves, as illustrated in figure 4 on page 17.

This figure, as the representation of the brain of a man of known intellectual power, Professor C. F. Gauss of Göttingen, is of value as an illustration not only of the general configuration of the organ, but also of specialities, showing diversities of form in the two sides of the brain.

Directly through the centre, separating the two hemispheres or sides, from *l* to *l* (fig. 4), is the great longitudinal fissure. The two halves of the brain proper lie closely together, but are separated by the band of *dura mater* named falx cerebri (fig. 1, 1). While, however, they lie parallel and close to each other, they can be drawn to some extent asunder, except that, towards the lower portion, they are held together by a transverse band, called *corpus callosum* (fig. 9, 1, p. 30). The three convolutions of each lobe are marked by the small letters (fig. 4), thus *a*, *a′*, *a″*, for those of the frontal, and so with *b*, *c*, and *d*, but that the lower or temporal lobe does not come much into view, and is only partially indicated on the turning at the right *c*, *c′* (fig. 4). It will appear on comparing the convolutions, that great prominence belongs to those two in the middle, so full in shape and continuous in their course, marked by the capitals A, A, and B, B, known as the ascending frontal and ascending parietal convolutions.

A comparison of the two hemispheres as given in fig. 4, shows that within certain limits a difference of arrangement may exist in the two hemispheres, which are in effect distinct organs, set in juxtaposition, and united together by intermediate fibres. A glance from right to left, over the successive lobes, reveals undoubted differences. This fact is very well shown both in the middle (*parietal*) and in the rear (*occipital*). While the two hemispheres are strictly analogous and capable of being divided in the same manner, there are differences in the fulness and foldings of certain convolutions. On the opposite page are two figures in outline from Professor Turner's *Anatomy*, which facilitate the work of reference to the convolutions. Professor Turner's figure of the profile differs from figure 3, by having the sides of the Sylvian fissure drawn together in the natural position, covering the central lobe, the island of Reil.

Though there are clearly marked dividing furrows common to every human brain, yet considerable diversities occur in the aspect of the convolutions. In a series of examples all showing elaborate foldings, there would be found much diversity in the form and relative size of different folds. This is well illustrated by the beautifully executed drawings (Plates I., II., V.), which accompany Rudolph Wagner's work on the human brain.[1] These Plates equally illustrate the fact that there is an appreciable difference in the arrangement of the convolutions on the two sides of the brain.

Importance must attach to variations which may be found as the result of the comparison of examples. The materials at command are not by any means sufficient to dispose of the question which here arises, for the results are far from uniform. Dr. Herbert C. Major, who has given great attention to these questions, has been led to remark on the number of exceptional cases which appear on any principle of comparison which may be adopted. He says, "As a general rule, great intellectual power is associated with a large and heavy brain. . . . Unfortunately, however, this is by no means an invariable rule, for instances are not wanting in which the brain representing superior intellect has not only not surpassed another lower in the intellectual scale, but has fallen below it."[2] Allowing for such exceptional cases, there are some general results of obvious importance. The mass and weight of the brain are not in themselves sufficient tests, for these sometimes belong to a diseased organ, and are in reality often symptoms of disease. Quality of brain must, therefore, be considered as well as bulk. Besides, it is clear that mass and weight of brain vary in some degree proportionately to the size and weight of the body. This is amply confirmed by comparison of the brains of animals of large proportions with the brains of animals of small size. Proportion between brain and body must therefore also be considered, as well as mass or weight in itself. And here it should be remarked that the relative weight of the brain to that of the body is greatest in early life. In childhood we have a much heavier brain proportionately to weight of body than we have in mature life. The brain starts in better condition than the body; but when growth begins the body greatly outstrips the brain in the rate of progress. From Tiedemann's observations, published in 1837, it appears that at birth the proportion of brain to body is "about 1 to 5·85 in the male, and about 1 to 6·5 in the female." Thereafter the proportion diminishes in the following ratio: at 10 years of age it is about 1 to 14; at 20 years about 1 to 30, and later than that about 1 to 36, after which the relative decrease is slight.[1] Thus it appears that it is not when we are at our strongest, but when we are at the feeblest stage of life that our brain is proportionately the heaviest.

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[1] Vorstudien zu einer wissenschaftlichen Morphologie und Physiologie des menschlichen Gehirns als Seelenorgan, 1ster Abh. 1860. See also the valuable coloured plates in the *Atlas d'Anatomie Topographique Du Cerveau*, by E. Gavoy, 1882; Ecker's *Convolutions of the Human Brain*, translated by Galton.

[2] *West Riding Asylum Reports*, vol. ii. p. 157.

The first set of these figures calls attention to a greater weight of brain in man than in woman. The following summary of results is given by Professor Turner:—"The average weight of the adult European male brain is 49 to 50 ounces (about 3 lbs.), that of the adult female 44 to 45 ounces, so that the brain of a man is on the average fully 10 per cent. heavier than that of a woman."[2] The following additional facts given by the same author must be taken along with this. The average weight of the body is less in women than in men. According to Thurnam's calculations, the average stature of women is "8 per cent. less than that of men." Besides, it is added, there have been many instances of upwards of 50 ounces (weight of brain) "in women where there was no evidence of high mental endowment."[3] Further, the limitations in most tables to Europeans, suggests that some regard must be had to educational and social influences. Thus Professor Turner, founding on the observations of Barnard Davis as to the African races, says, "Though the male brains are heavier than the female, there is not the same amount of difference in the average brain weight between the two sexes in the uncultivated as in the cultivated people."[1] On this question much will depend upon proportionate weight of brain and body, and this inquiry is confessedly complicated by the great variations occurring in both sexes. Quain gives us the following results from the tables of Clendinning, Tiedemann, and Reid—"In a series of 81 males, the average proportion between weight of the brain (encephalon) and that of the body, at the ages of 20 years and upwards, was found to be 1 to 36·5; and in a series of 82 females to be as 1 to 36·46."[2] These figures point to a smaller proportionate difference than comparison of mere weight of brain would have led us to expect.

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[1] Quain's *Anatomy*, vol. ii. p. 580.

[2] *Anatomy*, vol. i. p. 296.

[3] Turner's *Anatomy*, vol. i. p. 297.

Taking now general results as to weight, it seems clear that when the brain falls below 30 ounces there is imbecility. Such light weight of the nerve centres means general feebleness, want of physical development, incapacity for active effort, slight influence of education, and very limited responsibility for conduct, if not the entire absence of such responsibility. Over against this fact it is important to place another, that insanity is often the accompaniment of an unusually large brain. Numerous cases are recorded of mania with a brain weight of from 50 to 55 ounces, and a considerable number in which the weight was 60 ounces and above. In the West Riding Asylum Reports there are such examples as these,—a case of senile dementia, 61 ounces; melancholia, 60 ounces. At the same time, the great majority of cases of insanity present figures greatly below these. In the numerous examples of brain wasting there is of necessity loss of bulk and weight. Weight, therefore, when taken by itself, is not a sufficient test, though it must be one of the essential elements in our calculations.[3]

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[1] *West Riding Asylum Reports*, vol. iii. p. 7.

[2] Quain's *Anatomy*, vol. ii. p. 580.

[3] Some of Wagner's conclusions on this subject will be found in Quain's *Anatomy*, vol. ii. p. 571. It is striking to find the number of insane standing in the highest division of Wagner's Tables. Hirngewichts-Tabelle.—*Vorstudien*, 1ste Ab. 39.

All tabulated results show that, as a rule, those who are regularly engaged in active duty have a brain of good size and weight. In advance of this, a large number of men noted for high intellectual power have been distinguished by weight of brain. Dr. Thurnam has given the results of his observations in a paper "On the Weight of the Human Brain."[1] The following table, compiled mainly from his statistics, and from others furnished by Professor Turner, presents some of the results in striking combination:—

	Age.	Ounces.
Cuvier, *Naturalist*, ...	63	64·5
Abercrombie, *Physician*, . . .	64	63
Goodsir, *Anatomist*, ...	53	57·5
Spurzheim, *Physician*, ...	56	55·06
Dirichlet, *Mathematician*, . . .	54	55·6
J. Y. Simpson, *Physician*, . . .	59	54
De Morny, *Statesman*, ...	50	53·6
Daniel Webster, *Statesman*, . . .	70	53·5
Campbell, *Lord Chancellor*, . . .	80	53·5
Agassiz, *Naturalist*, ...	66	53·4
Chalmers, *Theologian and Preacher*, .	67	53
Fuchs, *Pathologist*, ...	52	52·9
Gauss, *Mathematician*, ...	78	52·6
Jeffrey, *Judge and Critic*, . . .	76	51·8
Babbage, *Mathematician*, . . .	79	49·5
Skobeleff, *General*, ...	39	51·3

Sir Robert Christison, who, along with Professor Miller, carefully weighed Lord Jeffrey's brain, favoured me with the following extract from his letter to Sir B. Brodie and Dr. Bright:—"The brain was much congested, and the arachnoid membrane contained much gelatiniform effusion. The encephalon weighed $51\frac{7}{8}$ ounces, the cerebellum $6\frac{7}{8}$ ounces."

In contrast with the above examples, we must keep in view such cases, mentioned by Wagner, as Hermann the philologist; Tiedemann the physiologist; and Hausmann the mineralogist, in whom the brain was below ordinary weight, being respectively $46\frac{1}{2}$, 44, and 43 ounces.[2] Besides, there are many examples of great brain weight without any intellectual distinction. The number of such cases is readily illustrated by reference to the highest figures in the table of 964 cases, prepared by Rudolph Wagner,[1] drawn from the observations of Virchow, Bergmann, Tiedemann, and others.

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[1] *Journal of Mental Science*, April 1866.

[2] It should, however, be stated that Tiedemann was 80 years of age, and Hausmann 77, so that the brain had doubtless diminished in weight from senile atrophy. The same remark may apply in the case of Jeffrey and of Babbage.

Besides mass and weight, the principal external features of difference are complexity of the convolutions, and depth of the groove or furrow by which they descend into the mass. There is a large amount of evidence in support of the position that in the less cultivated races the convolutions are far less ample in their folds than are the convolutions of the more cultivated races.[2] The converse seems to hold good in very many cases. The evidence supplied by R. Wagner,[3] and extended by his son Hermann, is, however, very strong in support of the conclusion that the brain of the man distinguished for intellectual power and activity is, as a rule, much more ample in its folds than the brain of his ordinary fellow-countrymen. Apart altogether from the possibility of an increased number of centres in such a brain, there is at least a larger superficial area. The exceptions to the rule are, however, both considerable in number and marked in character. There have been examples of men of high ability whose brain was not more complex in the folding of the convolutions than an ordinary brain, and there have been cases of a brain unusually fine in the waving lines of the convolutions, without attendant evidence of personal distinction.[4]

From outward configuration, I pass to the internal structure of the brain, distinguishing first the grey matter from the white. When a horizontal section of one of the hemispheres is made, the entire central portion is seen to consist of white matter, the surrounding grey matter running in upon it with promontories according to the depth of the convolutions. The effect is best appreciated by looking first at the grey matter, then at the white. If we allow the eye first to trace the distribution of grey matter, there is seen, all round, a rim of this matter, here and there increased in breadth by the furrow or groove between two convolutions. The deeper the furrow, the further the grey matter penetrates. This will be readily understood by reference to figure 10, p. 31. Again, looking at the same arrangements from the point of view afforded by the white matter, it seems as if the white, besides occupying the whole centre, formed a series of bays, as when the sea runs up into the land. These bays vary considerably in size, being smaller and more numerous towards the front and rear, while they are fewer in number, and wider on the side of the hemisphere. The grey matter completely encompasses the white matter, spreading not only over the entire exterior, but over the base, and inner side of each hemisphere. The depth of the grey matter varies at different points. Dr. Major made a series of investigations by passing a graduated glass tube through different parts. His conclusions may be stated thus:—"The depth of the grey matter of the cerebrum varies in different situations." The depth is decidedly greater in the frontal and upper middle (parietal) lobes, than in the back lobe. The lower middle (temporo-sphenoidal) is also deeper than the back lobe. The concealed central lobe (island of Reil) shows the grey matter always deep, in most cases, at least as deep as anywhere else.[1]

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[1] Vorstudien, 1ste Ab.

[2] Turner's *Anatomy*, vol. i. p. 295.

[3] Vorstudien, 1ste Ab.

[4] The question, what in process of the growth of the organ determines the form of the convolutions, is one to which as yet no very satisfactory answer has been given. It has been suggested by Dr. Halle (*London Medical Record*, 1875) that the shape of the skull determines the shape of the convolutions, by certain cranial axes resisting the process of growth and leading to the doubling back of the brain substance. This suggestion does not, however, carry an explanation of the marked diversities found among the convolutions.

This contrast of white and grey matter brings under notice two essentially different substances in the brain. The outer portion, wrapped together in convolutions, being the grey matter, is full of nerve cells. These are so numerous as to baffle calculation. From the number seen within a small section placed under the microscope, it is reckoned there must be very many thousands of them in the human brain. The cells are packed together in a glutinous substance, which Virchow has named nerve-glue (*neuroglia*). Each of these minute cells is found to have a nucleus or central point, around which its substance is gathered. The cells vary somewhat in form, according to the number of the fibres which they send forth, and which spread out in different directions. Of these cell-fibres there are often as many as four or five springing from the walls of the cell. The cells being crowded together, are probably connected by the fibres which they give forth. These fibres consist of nerve protoplasm, and some of them serve as the connecting lines between the cells and the nerve fibres, that is, the nerves proper; and the connection is so close that in some cases the cell-fibre passes into the nerve-fibre. The general aspect of the cells with their interlacing fibres will be seen by reference to the accompanying representation of a section taken from the front portion of the brain, showing the nerve cells as they are imbedded in the nerve-glue (fig. 7). There is considerable diversity not only in the form of the cells, but also in the manner in which they are grouped together. The most characteristic cells of the cerebral cortex are known as pyramidal cells, and lie with their long axis vertical to the surface of the convolutions. "The grey matter presents a laminated appearance, and as a rule consists of five or six layers, which are composed of the characteristic pyramidal nerve cells of the cortex of the cerebrum, of nerve fibres, of matrix or neuroglia (nerve-glue), and of blood-vessels."[1] In the second layer multitudes of small pyramidal nerve cells are situated; whilst in the third layer pyramidal cells, two or three times larger in size than the small cells, and

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[1] "New method of determining the Depth of the Grey Matter."—*West Riding Reports*, vol. ii. p. 157.

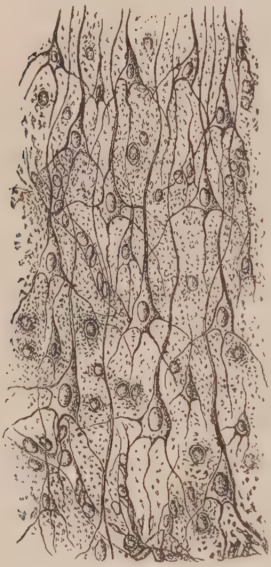

FIG. 7.—SECTION OF THE GREY MATTER OF THE BRAIN, magnified to show the cellular structure.

(*From* Turner's *Anatomy*.)

"Vertical section through the third and fourth layers of grey matter of the superior frontal convolution. Large and small-sized pyramidal nerve cells; the neuroglia, with its corpuscles and some capillary blood-vessels, are represented."

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[1] Turner's *Anatomy*, vol. i. p. 280.

more widely separated from each other, are found in considerable numbers. Betz has made the nerve cells the subject of special study, and he states that giant pyramidal nerve cells, about three times larger than the large pyramidal cells of the third layer, are found in clusters in the portion of the brain lying to the front of the fissure of Rolando,—that they are chiefly in the fourth layer,—that they have two principal fibres, and from seven to sixteen smaller subordinate fibres,—and that of the two principal fibres, the one is slender, and passes from the nucleus direct to a nerve fibre, the other is broad at its origin, and separated into divisions which go off towards the outer portion of the grey matter.[1] Lewis states that similar giant cells also occur in the superior and middle frontal convolution, and sparingly along the front of the ascending parietal convolution, deep in the fissure of Rolando. Dr. Lockhart Clarke also remarks that "not only in different convolutions does the structure assume, to a greater or less extent, a variety of modifications, but even different parts of the same convolution may vary with regard either to the arrangement or the relative size of their cells."

The white matter which occupies the central part of the brain is fibrous in structure. It consists of nerve fibres massed together in the interior, and entirely encompassed by the grey matter. This great accumulation of nerve fibre is composed partly of the nerve fibres which enter the brain from different regions of the body, and partly of fibres which unite different portions of the brain so as to constitute a compact vital unity. The latter are so numerous that the mass of nerve fibre which passes down from the brain to the spinal marrow is very much smaller than the body of nerve fibres congregated within the brain. The nerve fibres either extend from part to part within the central organ, or from it downwards and outwards to the peripheral distribution. These nerve fibres are very minute threads. In the brain itself they are sometimes as minute as a twelve thousandth part of an inch, whilst a nerve which passes down to some part of the muscular system may be one fifteen hundredth part of an inch.[1]

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[1] *Anatomischer Nachweis zweier Gehirncentren*, 1874, p. 578 ; and *Central-Blatt*, 1882.

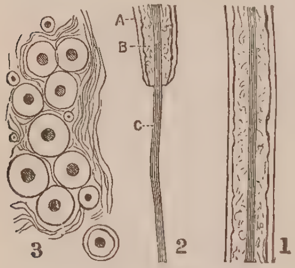

Fig. 8.—REPRESENTATION OF NERVE FIBRE.
(*From* Turner's *Anatomy*.)

"1. Medullated nerve fibres, showing the double contour. 2. A similar fibre in which A is the primitive membrane, B the medullary sheath, C the axial cylinder, protruding beyond the broken end of the fibre. 3. Transverse section through the medullated fibres of a nerve, showing the axial cylinder in the centre of each fibre. Between the fibres is the interfibrous connective tissue."

The ordinary structure of the nerve as found in any part of the body involves a threefold arrangement. There is in the interior the axial thread itself; gathered around this is a white marrow-like covering (the white substance of Schwann); and these two are enclosed within an investing membrane.

In the above figure (8), No. 1 shows the threefold aspect—the axial fibre in the centre, the white substance by which it is surrounded, and the enclosing membrane. In 1859 it was shown by Lister and Turner in a joint paper that there was a difference in chemical composition between the axial fibre and the marrow-like enclosure in which it is imbedded.[2] Working with a mode of preparation devised by Dr. Lockhart Clarke, they ascertained that the axial fibre became of a red hue by an ammoniacal solution of carmine, while the marrow substance was unaffected, and that the marrow-like substance became opaque and brown under chromic acid, while the fibre continued unchanged in appearance. In 1868 Dr. Ranke of Munich pointed out that the axial fibre has an acid reaction, the marrow substance an alkaline reaction.[3] In No. 2 of the above figure the axial fibre is shown protruding distinct from its enclosures. This fibre is first developed, and is thus the essential feature in the structure. No. 3 shows a section of several fibres as they are gathered together, presenting the extremity of the fibres and their membranes as they lie in the connective tissue. This illustrates the manner in which provision has been made for isolation of distinct lines of communication. It seems generally held that the membrane of the nerve fibres is not present in the brain itself and spinal cord. Professor Turner speaks with caution on the point. He says that the investing membrane "is believed to be absent from the nerve fibres in the brain and spinal cord." Observations are specially difficult here, as the different structures of the fibre are not visible in the living state, and changes in the tissue occur rapidly after death.

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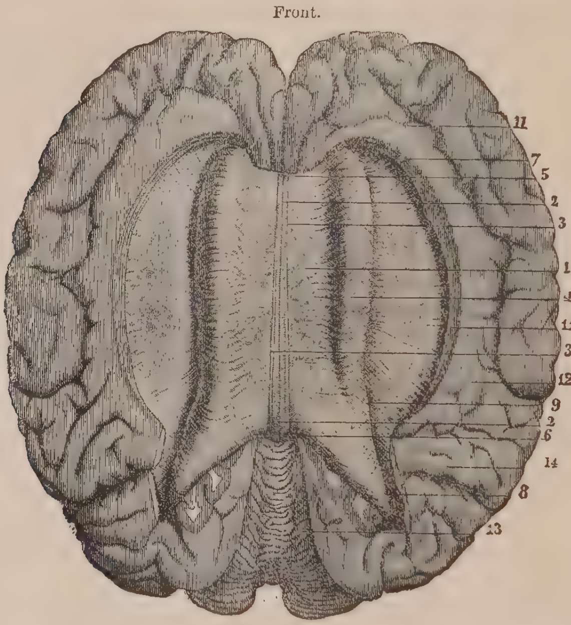
[1] Quain's *Anatomy*, vol. ii. p. 127 ; Turner's *Anatomy*, vol. i. p. 196.

[2] Observations on the Structure of Nerve Fibres.—*Quarterly Journal of Microscopical Science*, October 1859.

[3] *Die Lebensbedingungen der Nerven.* Leipzig, 1868.

If a cutting deeper than that which first reveals the contrast between grey matter and white be now made, we come upon a broad commissural band of connecting tissue (*corpus callosum*), which connects the two sides or hemispheres of the brain (fig. 9). The band here exposed consists of a closely compacted body of nerve fibres passing transversely from the one hemisphere to the other, and the transverse fibres have on their surface a few longitudinal fibres. The two hemispheres are thus constituted a single organ. This connecting band does not stretch the whole length of the hemispheres; but, being carried somewhat nearer the front than the back of the organ, holds the two sides firmly united in the centre, leaving them free or isolated only towards the forehead and towards the back of the head. Besides, the hemispheres are quite unconnected in the upper portions, until the level of the band now described is reached. They are thus in some respects two organs, while they at the same time constitute a unity. There is separateness, and yet there is solidarity. The connecting band is thicker and stronger at its two extremities than in the middle, and is somewhat stronger behind than in front. The transverse fibres of which the band is almost entirely composed pass not merely into the white or fibrous substance of each hemisphere, but also into the grey matter, constituting connecting lines between the convolutions on the opposite sides. This presents part of the explanation of the much larger mass of white matter within the nerve centre than that which passes forth to the spinal marrow. A further explanation is found in the existence of connecting lines which unite separate parts of the same hemisphere. The fact that fibres pass from hemisphere to hemisphere, connecting different portions of the grey or cellular matter, points towards the conclusion that there is co-ordination and co-operation of the opposite parts in providing nerve stimulus or innervation for ramifications of nerve fibre spreading throughout the body.



Cerebellum.

Fig. 9.—CONNECTING BAND WHICH UNITES THE TWO HEMISPHERES.

(*From* Quain's *Anatomy.*)

"The upper surface of the corpus callosum has been fully exposed by separating the cerebral hemispheres and throwing them to the side; the gyrus fornicatus has been detached, and the transverse fibres of the corpus callosum traced for some distance into the cerebral medullary substance.

1, the upper surface of the corpus callosum; 2, median furrow or raphe; 3, longitudinal striæ bounding the furrow; 4, swelling formed by the transverse bands as they pass into the cerebrum, 5; anterior extremity or knee of the corpus callosum; 6, posterior extremity; 7, anterior, and 8, posterior part of the mass of fibres proceeding from the corpus callosum; 9, margin of the swelling; 10, anterior part of the convolution of the corpus callosum; 11, hem or band of union of this convolution; 12, internal convolutions of the parietal lobe; 13, upper surface of the cerebellum."

If next we penetrate beneath this connecting band, we come upon a complicated arrangement of parts, presenting to view several distinct bodies, separated by a series of spaces (ventricles) filled with fluid. Of these ventricles there are five in all. Some of them are shown on fig. 10, along with a variety of bodies congregated towards the base of the brain.

In the central part of fig. 10, towards the back, sweeping in a semicircular form round the innermost visible point of the longitudinal fissure, is seen the posterior swelling of the connecting band of the hemispheres, (4). The two most conspicuous bodies in front are here the most important for my present purpose. These represent the largest nerve ganglion of grey and white matter at the base of each hemisphere

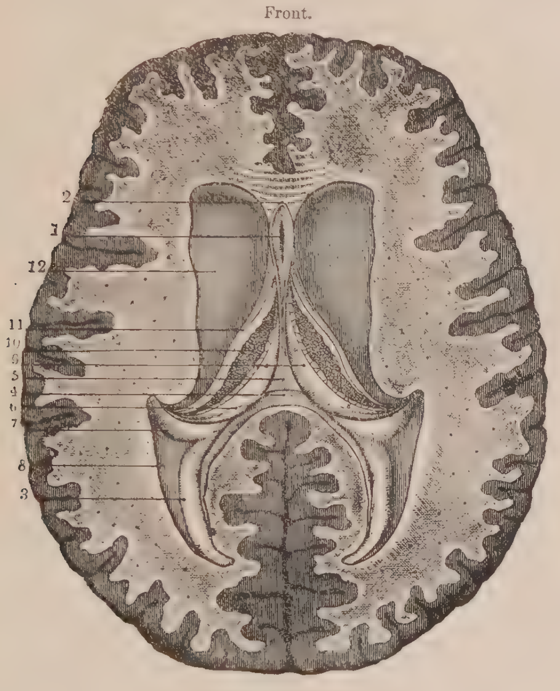


FIG. 10.—APPEARANCE OF THE HEMISPHERES BELOW THE CONNECTING BAND, WITH THE LATERAL AND FIFTH VENTRICLES.

(*From* Quain's *Anatomy.*)

"1, the fifth ventricle; 2, the two laminæ of the septum lucidum meeting in front of it; 3, lesser hippocampus of the posterior cornu; 4, horizontal section of the posterior swelling of the corpus callosum; 5, middle part of the fornix, where it has been separated from the corpus callosum; 6, posterior pillar of the fornix; 7, hippocampus major descending in the middle cornu of the lateral ventricle; 8, eminentia collateralis; 9, lateral parts of the fornix; 10, choroid plexus; 11, tænia semicircularis; 12, corpus striatum."

(12, *corpus striatum*). In close relation with these, lying to the rear, but a little lower (and scarcely appearing in this figure) is a second and somewhat smaller ganglion, similarly constituted, (*optic thalamus*). This ganglion as situated at the

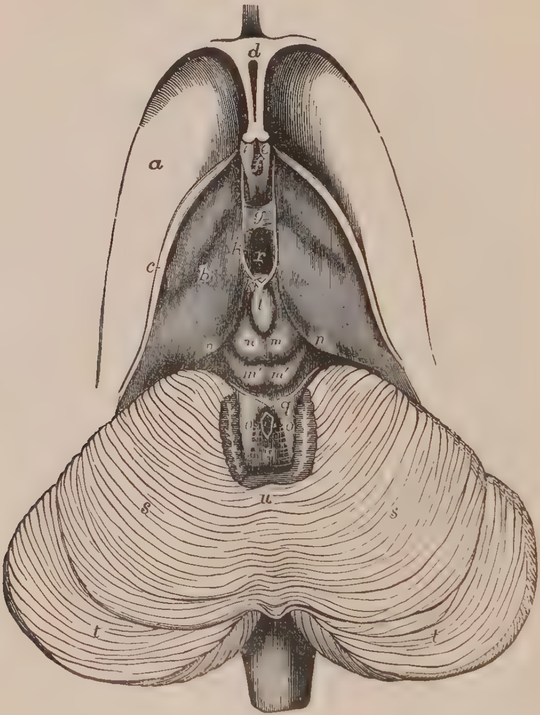


FIG. 11.—THE GREAT BASAL GANGLIA, WITH CEREBELLUM.

(*From* Turner's *Anatomy.*)

"A dissection to show the basal ganglia, and upper surface of cerebellum. *a*, corpus striatum; *b*, optic thalamus; *c*, tænia semicircularis; *d*, 5th ventricle; *e*, *e*, anterior pillars of fornix; *f*, anterior, *g*, middle, and *k*, posterior commissure; *l*, pineal gland, *h*, its left peduncle; *m*, *m*, nates; *m′ m′*, testes; *n*, corpus geniculatum internum; *o*, *o*, superior peduncles of cerebellum; *p*, valve of Vieussens; *q*, 4th nerve; *r*, 3d ventricle; *s*, *s*, anterior superior, and *t*, *t*, posterior superior lobes of cerebellum; *u*, upper surface of vermiform process."

base of the right hemisphere is seen on figure 13 (*Th*). The relation of these two principal ganglia at the base of the brain will best appear by reference to fig. 11 (*a* and *b*), which also shows the surface of the cerebellum, or little brain, in the rear. These two large bodies, an anterior and posterior in each hemisphere, are masses of nerve fibre, encompassed with grey matter, and are known as the basal ganglia, the anterior being largely made up of motor nerves, the posterior mainly of sensory nerves. In the centre (between the *optic thalami*) are four smaller basal ganglia (*corpora quadrigemina*, m, m, m', m'), which are composed of both grey and white matter. These four bodies are connected both with the cerebellum and with the optic thalamus, and are in close relation with the optic nerve.

If now the organ be turned with its lower surface upwards, we have a view of the base of the brain, with its convolutions (fig. 12); and at the same time, the lower surface of the cerebellum, of the bridge, and of the medulla, along with the origin of the leading cranial nerves. Immediately underneath the brain proper, and situated quite to the rear of its base, is the little brain, named the cerebellum. Its upper surface is represented on fig. 11, its under on fig. 12. It is held by two bands in close connection with the brain proper. In many features of structure it closely resembles the brain proper, for though smaller in size, it has its two hemispheres—its mass of grey matter, and its body of white matter or aggregate of nerve fibres. Notwithstanding these general marks of resemblance, however, it differs considerably in aspect from the brain proper. Its laminated appearance is due to narrow fissures passing from its surface into its substance. This is consequent upon the fact that the grey matter is laid down in very thin plates, into the most of which, however, the white matter runs as in the convolutions of the brain proper. A section made through the cerebellum presents an appearance as of the branches and foliage of a tree, which has led to the application of the fanciful name *arbor vitae*,—tree of life. In the white matter numerous fibres connect the cerebellum with portions of the nerve centre above and below; other fibres pass through the bridge, and connect correlated regions in the two hemispheres of the cerebellum; in the grey matter, there is a characteristic arrangement of nerve cells.

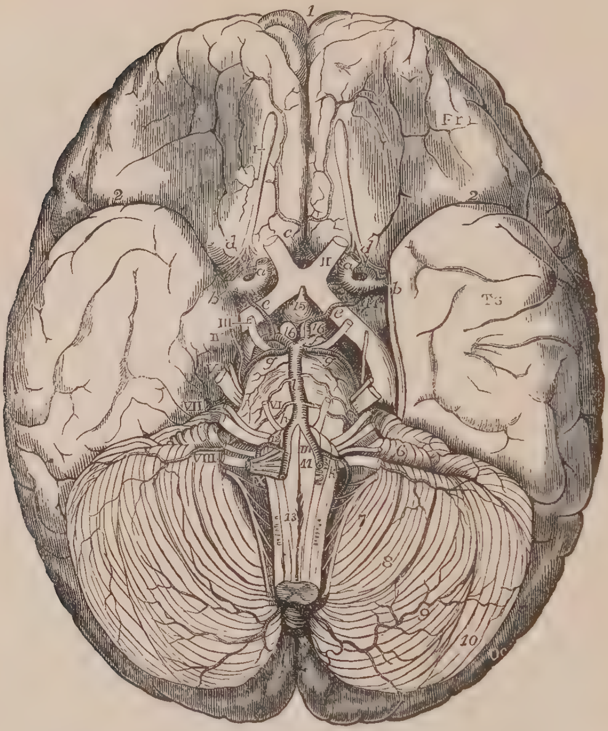


Fig. 12.—LOWER SURFACE OF THE BRAIN AND SUBORDINATE NERVE CENTRES.

(*From* Turner's *Anatomy.*)

"Diagram of the base of the brain with its arteries. I. to IX. cranial nerves; *Fr*, frontal lobe; *Ts*, temporo-sphenoidal lobe; *Oc*, occipital lobe; 1, great longitudinal fissure; 2, Sylvian fissure; 6, flocculus; 7, tonsil; 8, postero-inferior; 9, slender; 10, biventral lobes of cerebellum; 11, left anterior pyramid; 12, right olivary body; 13, decussation of the pyramids; 14, left anterior perforated space; 15, tuber cinereum and infundibulum; 16, 16, corpora albicantia."

The remaining portions of the great nerve centre will be best described by reference to figure 13, which illustrates their connection with the brain above, and at the same time shows the origin of the chief cranial nerves.

In the upper portion of fig. 13, certain parts of the brain are shown. On the reader's left, the convoluted part is the concealed central lobe, known as the Island of Reil. On his right is the inner and lower of the two basal ganglia, that

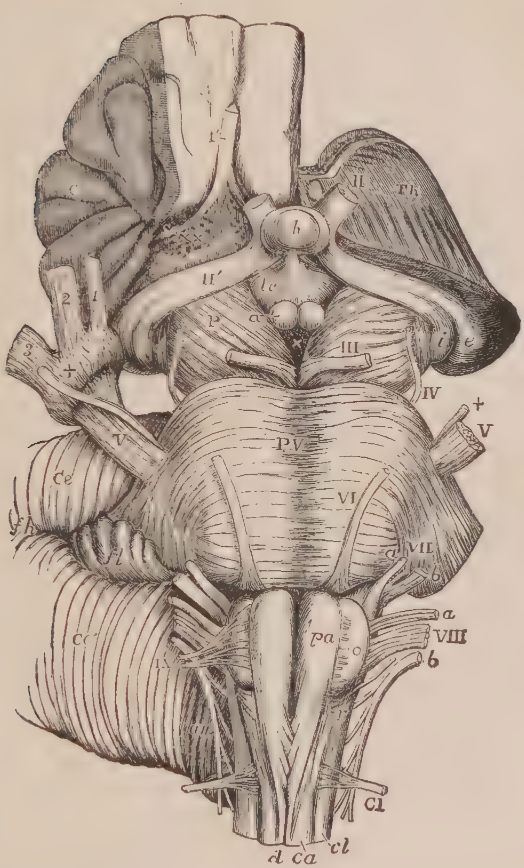


FIG. 13.—THE LOWER DIVISIONS OF THE NERVE CENTRE AS CONNECTED WITH THE BRAIN.

(*From* Quain's *Anatomy*.)

"On the right side the convolutions of the central lobe or island of Reil have been left, together with a small part of the anterior cerebral convolutions; on the left side these have been removed by an incision carried between the thalamus opticus and the cerebral hemisphere.

1′, the olfactory tract cut short and lying in its groove between two convolutions; II, the left optic nerve in front of the commissure; II′, the right optic tract; *Th*, the cut surface of the left thalamus opticus; C, the central lobe or island of Reil; *Sy*, fissure of Sylvius; × ×, locus perforatus anterior; *e*, the external, and *i*, the internal corpus geniculatum; *h*, the hypophysis cerebri or pituitary body; *tc*, tuber cinereum with the infundibulum; *a*, one of the corpora albicantia; P, the cerebral peduncle or crus; *f*, the fillet; III, close to the left oculo-motor nerve; ×, the locus perforatus posticus; PV, pons Varolii; V, known as the optic thalamus. Just below these, and diverging to the left and to the right, are the cerebral peduncles (*crura cerebri*), which are the bands of nerve fibres connecting the brain proper with the bridge, medulla, and spinal marrow. Just underneath these, in one solid mass, with transverse lines, is the bridge (*pons Varolii*). Immediately under this are four elongated bodies, two lying closely together next the middle of the organ, and two, more oval in shape, outflanking the middle pair. These four, together with other four behind, constitute the lowest division of the encephalon, the united mass being known as the medulla oblongata. To the left of the bridge and medulla is seen some tracing of the cerebellum, which considerably outstretches the two lower divisions of the encephalon.

The bridge is in close connection with the hemispheres both of the little brain and of the brain proper. In the bridge there is a combination of grey and white matter. The grey matter is distributed through the substance. Many longitudinal fibres run up through the bridge, from the medulla oblongata to the crura cerebri, and brain proper. Others pass transversely through it from one hemisphere of the cerebellum to the other, connecting them together. Thus the bridge is a pathway by which strands of communication pass between different divisions of the encephalon, and it serves as a bond of union giving compactness or solidarity to the entire organ.

The lowest portion of the encephalon (medulla oblongata) is an oblong body, about an inch and a quarter in length. It lies immediately below the bridge, and on the summit of the spine, so as to constitute the grand starting-point of the spinal cord. It is divided into two halves, each of which consists

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the greater root of the fifth nerve; +, the lesser or motor root; on the right side this + is placed on the Gasserian ganglion, and points to the lesser root, where it proceeds to join the inferior maxillary nerve; 1, ophthalmic division of the fifth nerve; 2, superior maxillary division; 3, inferior maxillary division; VI, the sixth nerve; VII *a*, the facial; VII *b*, the auditory nerve; VIII, the pneumo-gastric nerve; VIII *a*, the glosso-pharyngeal; VIII *b*, the spinal accessory nerve; IX, the hypoglossal nerve: *fl*, the flocculus; *fh*, the horizontal fissure of the cerebellum (*Ce*); *a m*, the amygdala; *p a*, the anterior pyramid; *o*, the olivary body; *r*, the restiform body; *d*, the anterior median fissure of the spinal cord, above which the decussation of the pyramids is represented; *c a*, the anterior column; *c l*, the lateral column of the spinal cord; CI, the suboccipital or first cervical nerve."

of four bodies. Two of these are shown on the figure, the anterior pyramids and the olivary bodies. Behind are the restiform bodies and posterior pyramids. The medulla oblongata is composed both of grey and white matter, after the manner of the superior portions of the nerve centre, and this holds good also for the spinal cord. The grey matter is distributed through the substance of the medulla. The white matter is arranged in bands or columns, of which, as we have seen, there are four pairs. These elongated bands of nerve fibre pass down from the medulla oblongata to the spinal cord. Some of these bands of fibre cross from the one side of the spinal cord to the other at the foot of the medulla, this crossing being known as the decussation of the fibres.

I shall only briefly refer to the provision for the nourishment of the great nerve centre. The arteries carrying the supplies of fresh blood pass up to the base of the brain. Some of these blood-vessels enter the interior of the organ to supply the ganglia at the base, and the white matter in the core. Others pass upwards by the outside of each hemisphere for the supply of the grey matter of the brain. These arteries sub-divide into numerous ramifications, carried in all directions on the delicate *pia mater* which descends into all the furrows between the convolutions. In this way, the fresh blood is constantly being carried over the entire mass of grey matter, and is let down into every little corner of its folds, where it is distributed by hair-like canals. A much larger portion of the blood for the brain goes to the grey or cellular matter than to the white or fibrous. It is reckoned that five times as much is constantly being supplied for the nourishment of the nerve cells as is provided for the nourishment of the nerve fibres.[1] This implies five times more demand in the one case than in the other,—five times more waste to be repaired. Along with this contrast, we have another, brought out by comparison of the brain with the body as a whole. We have seen[2] that the weight of the whole nerve centre, including all its parts in comparison with the weight of the entire body, is about

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[1] Turner's *Anatomy*, vol. i. p. 284.

[2] Quain's *Anatomy*, vol. ii. p. 570.

1 to 36, or 1 to 40. Now, according to the estimate of Haller,[1] one-fifth part of the whole blood-supply goes to the brain. In this we have a basis for estimating the importance of the organ, and the amount of activity involved in its ordinary exercise.

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[1] *Elementa Physiologiæ.*

CHAPTER III.

THE NERVE SYSTEM AS DEPENDENT ON THE GREAT NERVE CENTRE.

In the preceding chapter attention has been directed to the bands or columns of nerve fibres which enter into the constitution of the medulla oblongata. These fibres are continued into the spinal marrow, which gives origin to the greater number of the nerves which are distributed to the skin and muscles.

Before describing the spinal marrow, and its nerves, however, it should be stated that the great nerve centre within the head gives origin to several nerves, most of which are connected with the face and head, and known as the Cranial Nerves. Conspicuous among these are the nerves of special sense,—sight, hearing, smell, and taste. Along with these are the nerves which regulate the movements of the organs of vision; and others which control the manifold movements of the muscles of the face, thereby determining expression. Relatively to the surface occupied, a larger proportion of nerves is assigned to the face than to any other portion of the body. All these lines of nerves, while they are of the greatest importance, and most nearly related to the nerve-centres, are necessarily of limited extent. Their roots in the brain and their terminal organs are in close proximity. Others of the cranial nerves are associated with the movements of the tongue, with swallowing, with movements of the heart, and with the functions of respiration. Passing by these meanwhile, I shall in the first instance trace the distribution of the nerve system over the body.

The spinal marrow, elongated in form, lies in the spinal canal within the backbone, where it is enclosed by three membranes such as cover the brain. In harmony with the bilateral arrangement seen everywhere in the nerve centre, the spinal marrow is arranged in two halves, and terminates below in a pointed extremity. We cannot, indeed, speak of hemispheres, but there are still two halves, marked out by a clearly defined fissure in front, and by another behind. These fissures separate the spinal cord superficially into two sides, which, as in the brain, are connected by transverse commissural fibres. Here also we have both the grey matter, with its characteristic multipolar nerve cells and nerve glue, and the white or fibrous substance. But the positions of the two are reversed. The white matter is here the external, lying nearest the walls of the spine. The grey matter is surrounded by the white, and is at some points more abundant than at others. With its blood-vessels and connecting fibres, it is spread out as with horns curving towards the places where the nerve fibres make their exit from the spinal cord. This will appear from the following figure (14).

The white matter is arranged in columns, and these are subdivided into tracts of fibres, each of which ascends into the medulla-oblongata, to end either in it or in some other division of the encephalon. From each half of the cord nerves arise which pass out of the spinal canal between the vertebræ. In this way there are in all thirty-one pairs of nerves, taking distinct courses throughout the body. These are known as the Spinal Nerves, in contrast with the cranial nerves. Each one of the spinal nerves springs from two roots, anterior and posterior. On the posterior division, just after it has issued from the spinal canal, there is a ganglion or enlargement, through which the nerve passes. There is no such ganglion on the anterior division. Just beyond this ganglion, the two roots form into one, constituting a spinal nerve trunk. After the roots have been thus united the ramification of the nerves

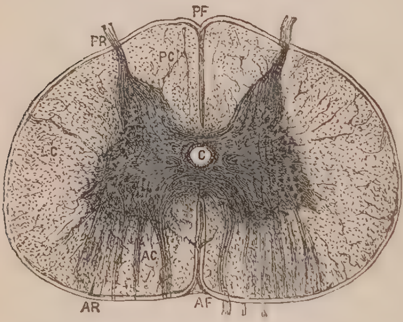

FIG. 14.—SECTION OF THE SPINAL CORD, SHOWING THE RELATION OF THE WHITE AND GREY MATTER.

(*From* Turner's *Anatomy*.)

"Transverse section through the spinal cord. AF, antero-median, and PF, postero-median fissures; PC, posterior, LC, lateral, and AC, anterior columns; AR, anterior, and PR, posterior nerve roots; C, central canal of cord, with its columnar epithelial lining. The pia mater is shown investing the cord, sending processes into the anterior and posterior fissures, as well as delicate prolongations into the columns. The crescentic arrangement of the grey matter is shown by the darker-shaded portion."

takes place. This is effected, first, by the nerve trunk dividing into two parts, the one passing off to the rear of the body, the other to the front. These are not a mere reappearance of the two branches issuing from the spinal canal. Each division contains a portion of the fibres of each of the two roots which come from the spinal cord. These two roots, as we shall see, have distinct functions, the rear line being nerves of sensation; the front, motor nerves. A share of both finds its way into each ramification. The fibres in each division have different areas of distribution. The one set (motor) pierces into the interior of the muscles; the other set (sensory) takes its course so as to end in the skin.

Attention should now be directed to the distribution of the fibres. The one set (motor) while penetrating into the substance of the muscle, has the nerve strand divided, and again subdivided, as one part after another of the tissue is reached. This process of subdivision proceeds so far, that at last even the single fibre itself divides. As to the termination of this very delicate process, there seems to be diversity of opinion. Some maintain that it ends in a very fine network; others that it ends in a more compact plate, situated within the muscular fibre. In the manner now described, the muscle is taken possession of, and is thus placed in vital connection with the nerve centre. The divisions and subdivisions found in a single muscle do not constitute isolated lines of communication. By a series of connecting fibres they are bound together, so as to constitute a network of controlling fibres, known as a nerve plexus. In this way the nerve fibres in a muscle constitute a unity, and all parts of the muscle move together as by the strain upon a single cord. This unifying process becomes more complex according to complexity of muscular arrangement. The nerve strand for a special muscle or order of muscles is connected with other strands farther up the system; and thus, in order to secure co-ordination or symmetrical movement of the several parts of the limbs, the arrangements of the nerve-plexus become more complicated.

The other set of nerves (sensory) take an outward course. The fibres of this order find their way to the surface of the body, where they are distributed to the papillæ of the skin, where each fibre terminates in a kind of expansion or bulging. In this way the termination is sensitive to external influence, even the slightest impact. This terminal expansion is known as an end-bulb, or touch organ. Some sensory nerves pass to the mucous membranes, where they often end in bulbs, sometimes simply in a pointed fibre; but at other times, the nerve twists round and forms a coil. Besides these varieties of terminal form, there are, towards the extremities of some of the sensory nerves, sets of small granular bodies, visible to the naked eye (corpuscles of Pacini). These are gathered around the nerve fibres which pass to the more sensitive parts of the body, such as the fingers, toes, arm, and neck. The following illustration (fig. 15) indicates their appearance.

These corpuscles are most numerous towards the extremity of the nerve, as illustrated in No. 1 of the figure. When greatly magnified, as in No. 2, the corpuscle is found to have a stalk, with a nerve-fibre passing up through the centre of the enlarged body. When inside this body, the minute fibre loses its usual sheath, and is surrounded by layers of connective tissue, within which is a gathering of transparent protoplasm. These corpuscles probably increase the sensitiveness which otherwise belongs to the sensory nerve.

From the general description given in this outline, it will be seen that the nerve system, so far as it is here under observation, consists of two distinct lines of communication. These have been universally recognised since Sir Charles Bell laid the results of his researches before the Royal Society in 1834.[1] There is one order of nerves essentially related to the muscular system, its extreme ramifications being all lodged within the muscles. This order uniformly issues from the front of the spinal marrow. This anterior division is indeed afterwards combined with the posterior (sensory), but only to be thereafter distributed in combination for the several parts of the body. There is no confusion of the two orders. The lines which are completely distinguished as they pass out from the spinal cord, continue distinct throughout. On account of the direction taken by the nerves distributed to the muscular system, and the function which they fulfil, they are called not only motor nerves, but *efferent* or out-carrying nerves, and sometimes centrifugal. As nerves of motion, it is their function to carry

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[1] *The Nervous System of the Human Body.*

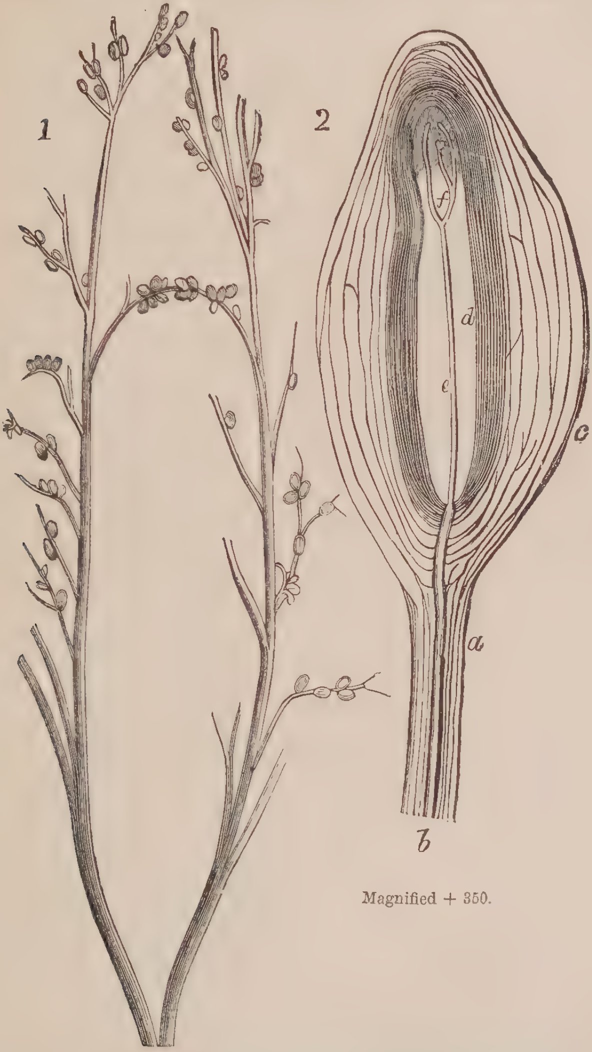

FIG. 15.—CORPUSCLES FOUND ON SENSORY NERVES AT THE MORE SENSITIVE PARTS OF THE BODY.

(*From* Turner's *Anatomy*, after Kölliker.)

"1. Nerves of one finger with the Pacinian corpuscles attached; 2. a Pacinian corpuscle × 350; *a*, stalk or peduncle; *b*, nerve fibre in stalk; *c*, external layers of capsule; *d*, inner layers; *e*, non-medullated nerve fibre in the central core; *f*, branching of terminal end of nerve fibre."

impulses from the centre so as to move the muscles with which they are severally connected.

The other set of nerves, which issues from the back of the spinal cord, may, as naturally as the former, be said to go out from the centre to the surface of the body. But, in view of their function, which is to carry impressions from the surface to the centre, they are named not only sensory nerves, but also *afferent* or in-carrying nerves,—that is, nerves which, as soon as an impression is made upon them, carry that impression upwards in the direction of the centre. These are also named centripetal.

We have thus two entirely distinct arrangements in the nervous system. By one branch, nerve influence is carried from above downwards; by another branch, nerve influence is carried from below upwards. The one accomplishes muscular movements; the other transmits sensory impressions. Fibres of these two distinct orders run alongside each other, and are even wonderfully interlaced, but without functional disturbance. The conducting line or axial cylinder of each nerve fibre being surrounded by medullary matter, and enclosed within a membrane, is kept in isolation for transmission of a distinct message.

Though the two orders of nerve fibre are distinct in function, they are alike characterised by excitability, and nothing is known concerning their action which seems to warrant the supposition that there is any difference in the nature of the nerve lines, or of the influence under which they come into play, or of the molecular change consequent upon their use. The only recognised difference between the nerve lines is found in the mode of distribution. The condition of vital activity is the same for both,—discharge of nerve energy from the grey or cellular matter. The marked difference of action depends, in the case of the motor nerves, upon impulse from the brain centre along the line; in the case of the sensory nerves upon impression made on their peculiar terminal structure. But in both cases, vital connection with the store of nerve energy in the grey matter is needful, in order that the excitability of the nerve fibre may be maintained.

Keeping in view the common features of the two sets of nerves, we may next treat more especially of the distinctive function assigned to each.

One division of the nerves regulates all movements of the muscles. These motor nerves are so connected as not merely to provide for separate action of distinct parts of the body, such as an arm or a finger, but also for co-ordinated action of several parts for a single end, as in walking or leaping. On account of the muscular system being acted upon by impulses transmitted from the centre, and for a definite purpose, the muscle so moved has been named "a voluntary muscle," in contrast with "involuntary muscles," such as in the heart or stomach, which move independently of the will. In the same way, the nerves which produce muscular movement, such as the motion of the hand in writing, are sometimes spoken of as voluntary nerves. This is a figurative use of the term voluntary or volitional, which can hardly be misunderstood. Neither the muscles nor the nerves are voluntary, but these two are the "instruments of volition," to use the phrase of Sir Charles Bell. Yet there may be need to guard against the risk of misapprehension here. And this is most effectually done by remarking that the so-called "voluntary" nerves and muscles may act involuntarily, as in the case of "reflex actions," that is, actions which are the result of sensory stimulus without consciousness. Besides, it must be remarked that this use of the word "voluntary" or "volitional" is already a draft on the department of experience. Neither anatomical nor physiological observation accounts for the use of the term. The only thing which we are at this point warranted to affirm as bearing on the action of motor nerves and muscles, is that they are moved by impulses proceeding from the nerve centre.

The other division of nerves is distinguished by special susceptibility at the extremity to impression from without. All the nerves of this division carry the impression from the extremity of the line to the nerve centre. In this way, even changes of temperature influence the body, and the slightest touch of a finger gives occasion for a message to the terminus. It thus appears that functional activity in this case depends upon susceptibility of the terminal part of the nerve to touch. If the external object, after touching, remain in contact, there is not a continuous communication. The sense of contact is gradually lost, and is not clearly restored except by movement of the object, or movement of the part in contact with it. If strong pressure be applied to the terminal region, the susceptibility of the nerve is for the time suspended. A prior freedom from pressure is needful at the point of contact in order that functional activity may take place at the moment of contact.

Besides this sensori-motor system now described, there is a distinct order of nerves connected with the lungs, stomach, and other viscera. This is an order not in the same way connected with our experience, and not under our control. I shall not occupy space with detailed description. It is known as the Sympathetic System. As a system, it is closely connected with the cerebro-spinal system, for the two are bound together by connecting fibres. The main part of the Sympathetic System consists of two gangliated cords containing nerve cells, which run down outside of the spinal column, one on each side of it. From these cords the fibres are distributed to the different organs already indicated.

The two divisions of nerves belonging to the cerebro-spinal system, the sensory and the motor, have their common meeting-place in the grey matter of some portion of the nerve centre. This holds true whether the nerves ascend as far as the brain itself, or terminate earlier. As we have seen, the grey matter, with its nerve cells, is found not merely in the brain proper, including the basal ganglia, but also in the subordinate divisions of that centre, and in the spinal cord. Its primary functions are determined by its situation and its structure. As to its situation, it is the essential feature of every division of the nerve centre; as to its structure, it is entirely distinguished from the nerve fibres accumulated within the centres.

Taking first the structure of the tissue, we have under review a complete contrast with the white matter. Wherever the grey matter is found, its essential structure is the same. Its masses are storehouses of nerve cells packed in nerve glue. In these nerve-cells nerve-energy is generated and stored; and provision for continual reproduction of this energy is made by the large blood-supply which is pumped up to the cranial region by night and by day, in sleeping hours and in waking. The whole nerve system, down to its most remote extremities, is kept in readiness for action only by continual storing of nerve energy in these cellular regions. On this point there is perfect agreement among physiologists.

Glancing next at the situation of the grey matter, we perceive the distinctive feature of a nerve centre. While the nerves spread outwards, the grey matter is massed here. In this way, the spinal cord itself must be regarded as a part of the nerve centre. In strict accordance with this characteristic, investigations have shown that it operates as a centre of reflex action. And, in so far as we have separately organised masses of grey matter in the medulla, bridge, cerebellum, and brain proper, we recognise those bodies as distinguishable portions of the great central arrangement of the nervous system.

Taking now together the central organs and the communicating fibres, we must contemplate the whole as one system. And here it is needful to dwell on the conditions of functional activity of the system, additional to vital connection with the stores of nerve energy. The nerves of sensibility depend for exercise upon excitement of the nerve at its peripheral termination. The effect of the impression made on a sensory nerve is carried along the whole line to the nerve centre. Questions concerning the experience consequent upon such transmission are reserved for a later stage of inquiry. Here I speak only of excitability of nerve fibre. When we turn to the other set of fibres, the motor nerves, the question as to the additional conditions of their exercise is more difficult. These fibres are acted upon from within, and action at the centre cannot be observed as we notice influence exerted on the surface of the body. Here we are practically without observations, and this state of things must continue. The normal action of the grey matter does not even come within the range of personal experience, and we are also shut out from that avenue of knowledge. Whether different portions of grey matter have entirely different functions, one part restricted to reception of sensory impressions, another to the discharge of motor stimulus, or whether these functions may be combined in the several parts, are questions difficult to decide. Some light will be thrown on these perplexities when reference is made to the results of electric stimulation of the grey matter. The nerve cells vary greatly in size, and they occupy different positions, but their common features seem to warrant the inference that they have common functions. And in this connection it may be remarked that the excitability which is common to both sets of nerve fibres implies movement, not only in the fibre, but in some sense in the correlated cells. Transmission of impression involves vibration as certainly as this is implied in tension and relaxation of the motor nerves. Accordingly, we must regard motion as characteristic of functional activity of a sensory cell, as well as of a motor cell. In this sense we may say that all cells exert motor influence, thereby granting that the grey matter has a double function of receptivity and activity. I say the double function, for, if it be admitted that there are sensory cells, and that these induce a form of activity, it will be granted also, in view of the familiar facts of reflex action, that the motor cells are receptive. In reflex action, sensory impression is the occasion of movement, without our being conscious of influence exerted upon us, or of influence being exerted by us. If we allow separate cells for the distinct effects, we grant that there is a sensory cell, which is receptive, and at the same time active in being receptive; and we also grant that there is a motor cell which is receptive of impulse transmitted from a sensory cell, in order that it may be active. There may indeed be several cells at each point influenced, but the conditions of functional activity remain the same. Voluntary movement, however, raises a distinct problem.

From the considerations now adduced bearing on the action of sensory and motor nerves, with that of their correlated cells, we are led to the conclusion that the stores of nerve energy in the grey matter of the brain need some agency to operate upon them in order that the energy may be liberated for actual work. During the period of inaction, the vital connection subsisting between the storehouse of nerve energy in the brain and the lines of communication spread over the body, keeps up the excitability of the nerve lines, by reason of which they are sensitive to impression. The state of sleep, involving cessation from effort with continued coursing of blood-supply through the brain, provides against exhaustion, which would arise from constant working. But in the active state a force beyond the store of nerve energy must operate in order to liberate some portion of that energy, thus bringing into action one or more of the connected fibres. Some impact must occur at the surface of the body, in order to act upon the excitability of the sensory nerve. Some power must be exerted at the centre, in order to bring into exercise a motor nerve. At the same time, the relation between sensory and motor cells is such that a single impression from without may operate first on the sensory nerve, and next through it upon the motor. This is the case in reflex action. A similar circle may be completed under influence from within the organism, as for example under the power of physical appetite, such as hunger. Immediately beyond this arises the interesting question, most difficult to answer, how far the movements of animals can be included within the class of sensori-motor or automatic actions. Beyond this again is the still more interesting question,—more directly connected with the present inquiry,—what variety of agents is found to operate in human life causing the use of the motor nerves. For an answer to this question we must travel beyond the bounds of the present department of inquiry, passing beyond anatomical and physiological facts into the region of personal experience. Meanwhile, having remarked that impulse beyond nerve energy is required to bring the nerve into action, it is clear that only some forms of human action, or parts of action, come directly under external observation. If "voluntary" or "volitional" activity exist as a distinct form of human action, it is not discovered by physiological science. Whatever views we may be disposed to entertain concerning the possibility or impossibility of voluntary action on the part of the lower animals, these views cannot well be regarded as more than hypothetical. While, so far as human activity is concerned, it is the clear testimony of experience, that human action is not invariably dependent on excitation of the sensory system, but activity often has its source in personal determination which is not accounted for by action of the nerve system.

Reserving the perplexities of this question for a later stage, we have further to consider here the molecular changes which occur in the grey matter, consequent on activity of the nerve system. When a demand is made on the stores of nerve energy by the exercise of either a sensory or a motor nerve, there are certain molecular changes as the direct result. In the nerve centre these changes are the expression of what is otherwise expressed in the external sphere. The force exerted means energy liberated and discharged, involving loss or waste in the organ which generates that energy. As a consequence, there is a demand for restoration of energy by nutrition. To some extent the molecular changes in the human brain have been matter of observation. There are cases on record in which, by accident, or amongst the disasters attendant on war, part of the cranium has been carried away, and some part of the brain exposed. In such cases, the pallor of the brain with exhaustion, such as, in extreme cases, may be seen on the countenance, and the flushing of the grey matter with fresh blood-supply after a meal, were clearly seen. Further, the whole series of experiments on the brain of living animals under anæsthetics, afterwards to be considered, has made us familiar with the exhaustion which soon follows upon action, and which soon renders discontinuance of the experiment needful. It is, therefore, one of the clearly ascertained results in physiology, that molecular changes in the brain are consequent upon impulses propagated along the strands of nerve fibres. The grey matter has it as its primary function to evolve nerve energy, and that is drawn upon by every form of nerve action. This applies wherever the grey matter is found. Accordingly the law will apply equally to the brain proper, the little brain, the bridge, the medulla, and the spinal cord. Experimental evidence amply confirms this position.

A further question there is, as to the degree of exhaustion which may occur at the nerve centre under the activity of the nerve system. Exhaustion will be proportionate to exercise. The more intense the labour, the sooner we must have the sense of waning force. I say nothing here as to the difference between mechanical and intellectual labour. However familiar the work done may be to the worker, the time soon comes when there must be a cessation from activity. Hence the need not only for nourishment, but also for repose in sleep, when demand is abated, while the nourishing process is continued with what may be stated as redoubled power.

Having thus spoken of the primary function of the nerve centre as that of providing nerve force, may we further speak of the grey matter as itself distinguished by sensibility? If it be the centre to which sensory impressions are carried, is the brain itself to be regarded as a sensitive organ? A large number of surgical operations carry a distinct answer to this question. Protruding parts of the brain have been cut away without any sense of pain, and without the appearance of the loss having caused any disturbance to mental action. "Whole masses of brain may be destroyed by disease, or actually removed, with impunity; that is, without any immediate influence on the mind, or on the power of motion or of sensibility."[1] What is known as "the American crow-bar case" is one of the best and most familiar examples on record.[2] I give the narrative in condensed form as presented by Dr. Ferrier. "Through an accident in blasting a rock, a young man was hit by a bar of iron, which, entering at the left angle of the jaw, passed clean through the top of his head in the left frontal region, having traversed the anterior part of the left hemisphere. This man speedily recovered, and lived for thirteen years afterwards without manifesting any special symptoms which could be attributed to such a serious injury to the brain."[3] These quotations really throw light on the deeper question of the relation of integrity of brain substance to normal activity of mind, but I am content meanwhile to use them as illustrations supporting the position that there is not the intense sensitiveness in the grey matter of the brain which might have been expected in view of the fact that it is the great centre for sensory impressions. Great sensibility to impression there is at the periphery; whenever that sensibility is affected there is immediately transmission of a message to the brain, but facts do not warrant the supposition that the message is delivered at the central organ by a simple repetition of what has occurred at the extremity of the nerve line. The seat of sensibility is recognised by us as the finger, toe, or arm, as the case may be, but this is not the result of sensibility at the centre being correlated with sensibility at the finger, toe, or arm. That there is transmission of influence is beyond doubt. If a nerve fibre be cut at any point in its course, there is temporary insensibility at the point from which the fibre comes, or temporary loss of motor power, as the case may be. In course of time, the severed parts may be reunited,[1] and the power of communication restored. The necessity for integrity of communication is thus manifest. But facts are against the supposition that the message is delivered by acting upon a sensitive surface in the grey matter. There is action upon the nerve cells, and consequent molecular change, but there is not sensibility in the grey matter as there is in the white or fibrous. This conclusion as to non-sensibility is favoured by the similarity of the cells in the grey matter, in harmony with the depth of the layer in which they are found.

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[1] Sir Charles Bell's *Nervous System*, p. 208.

[2] Reported by Dr. Bigelow, *American Journal of the Medical Sciences*, July 1850.

[3] *Functions*, p. 126.

Here it becomes possible to indicate certain general characteristics of nerve action. We have a graduated series of nerve centres, charged with nerve energy, and constantly maintaining in a state of vital activity the whole extent of the nerve system, with its sensory and motor nerves. These centres and lines of communication are formed in the embryo,—they exist in the infant,—they are exercised by the child in the earlier and simpler stages of action belonging to them,—and in mature life they operate with certain advantages acquired in accordance with the laws of normal exercise. These laws, so far as yet clearly recognised, are mainly concerned with the action of the nerve fibres, for we are still ignorant in great degree of the laws which regulate the action of the convolutions of the brain and grey masses of the subordinate centres. At this point we make account mainly of these two characteristics: excitability of both orders of the nerve lines, and equal dependence of both on the nerve energy stored in the grey matter. Along with these characteristics, we must draw to some extent on the facts of personal experience, leaving detailed analysis of this experience for a later stage. On this region of experience I draw meanwhile only so far as to remark that we have some personal power to determine what nerve lines, sensory and motor, shall be brought into use. Nerve force will indeed operate as the result of slight impression from an external object, and, consequent upon this, further operation of nerve force will be manifested in the action of motor nerves, thus giving rise to reflex action. To this extent it holds true that nerve force may be liberated by influence from without. In this way, and by action of vital organs within, certain nerve tracts are kept in regular use. But we know in personal experience that by our own determination both sensory and motor tracts may be brought into play. Besides the spontaneous use, there may be a voluntary use of nerve energy. I make here no further attempt to define this voluntary use than by remarking that it is not spontaneous response to external influence, and not the result of functional activity of other organs distinct from the brain. Now, there are some laws of nerve action which come into view only in connection with this voluntary or personal direction of nerve energy.

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[1] Carpenter's *Principles of Human Physiology*, seventh ed., p. 506.

The most general aspect of the law of exercise may be stated thus: *Frequency of use gives increased conductivity.* Müller, when treating of "voluntary movements," incidentally states the fact thus: "the conducting power of the nervous fibres increases with the frequency of their excitement."[1] This general statement, in the first instance, merely indicates what is familiar to us in the use of our faculties, that use leads to growth of power. This holds true of the muscular system, and, as muscular action is dependent on nerve action, what is now remarked is only the extension of the same law to the higher controlling power. But the law wears a different aspect when applied to the nerve system. It does not imply that a nerve line becomes stronger, as a muscle does, by use. Something much more important is involved, and more in harmony with the functions of the nerve system. Keeping in view the relation of the nerve centres to the nerve fibres, it implies a more prompt and copious discharge of nerve energy from the centre, and more ready and powerful action of the nerve lines. The general law has thus a double significance, bearing at once on facility and on intensity of action. And for each of these aspects of the law there is distinct application to the nerve centre, on the one hand, and to the lines of communication on the other. Facility must be interpreted as having two aspects, the one concerned with the discharge of nerve energy, the other with communication of influence along the lines, or ready transmission along chosen tracts. Intensity must in like manner be viewed in a double relation, as it applies to amount of energy put forth, and amount of work done. These aspects of the general law are simply illustrated by the familiar facts connected with development of powers of observation and locomotion in early life. The child at first sees objects promiscuously, next is attracted by moving objects, or by those of bright colour,—and only by practice in the exercise of observation comes to concentrate on particular objects, or aspects of an object. So it is with locomotion. The child first attempts to steady itself on its feet,—then to put one foot before the other in balancing the body,—and thereafter acquires the power of running without concern. The chick greatly excels the child in easy control of its movements. From this it may follow that what the child does is greatly more complicated than what the chick does. I do not at present dwell on the question raised by this contrast, but only point out the illustration of the general law of the development of nerve power as illustrated in the early life of a child. More extended observation confirms this law. Illustrations are, however, more easily obtained from the motor nerves than from the sensory, because the discharge of nerve energy is more marked in the one case than in the other. On this account we more readily attribute *facility* to the action of motor nerves, *intensity* to the force or impression received along a sensory nerve. But both phases apply equally to motor and to sensory nerves. Thus the blind man, who depends largely on sensibility of the finger-points, finds that the readiness of application and amount of impression are greatly increased by practice, unless, indeed, manual labour harden the skin and thus interferes with the natural development of sensibility of nerves. So as to the motor nerves, the violinist, as he becomes a skilled performer, finds that he commands his instrument at once with more ease and with more power. The nerve energy is turned easily in the familiar direction, and the lines of communication are easily worked. A deep cut into the left hand, occasioning injury to the nerve, of the violinist destroys for the time his power, and makes it needful for him, when the nerve lines have been reunited, to regain and re-establish his power over the fingers of that hand; but the facility with which this is done illustrates the truth of the law whose applications are now under consideration.

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[1] Müller's *Elements of Physiology*, transl. by Baly, vol. ii. p. 939.

From the more general statement applicable equally to the sensory and motor nerves, it is needful to pass to a more restricted view of the application of the law as it is concerned with the distinctive features of each class of nerves.

Repeated use of a sensory nerve results in increased susceptibility of the conducting fibre. This is familiarly illustrated by the quickness and acuteness of impression in the case of those whose occupations make special demands upon distinct nerves of sensibility. A person who has trained himself to distinguish sounds in a mountainous district can discriminate both as to quality and direction, while one who has not thus trained himself cannot. One who is constantly at work amongst cloths of different fabric can tell, by a touch of his finger, what an inexperienced person could not do without careful inspection. There was in Glasgow a blind man known to me, whose business was that of a dyer, and who could by touch most accurately distinguish the colour of the cloth submitted to him. The different effects of the dye employed could be discriminated by tactile impression. In such cases as those adduced there is, I doubt not, more involved than illustration of increased sensibility of nerve by training; but I am content meanwhile to take them simply as illustrating the point under observation. Under this law we find the explanation of many of the phases of sensibility peculiar to individuals. Some of these are to be explained by a nervous sensibility originally more acute than ordinary; but most by induced susceptibility under the law of activity now explained.

In this relation it must, however, be kept in view that there is a very marked restriction upon the law of increased power by frequency of use. Restriction is imposed, not only by need for rest, as in the case of all nerve fibre; but by the risk of overstrained use, either as the result of over-continuance at a time, or too frequent excitement. In other words, the excitability of the sensory nerves can be so acted upon as to induce an irritability which interferes with easy and normal action of the sensory nerves.

Attention must next be turned on the phase of the law as specially applicable to motor nerves. *Repeated use of a motor nerve or set of nerves secures increased facility and power of muscular control by means of the conducting fibre.* This is illustrated by acquired movements, such as those involved in swimming or skating. The movement is at first difficult of accomplishment. The felt uncertainty of movement occasions apprehension of danger. But repeated effort brings the motor nerves more completely under control, making the movement not only easy, but a source of pleasure. From this time the nerve centre and the set of nerves brought into exercise have an established relation. A facility of co-ordinated action is established. It is equally true as a description of the result, that the nerve energy passes easily to the nerve lines concerned, and that the nerve lines have a predisposition or preparedness for action. Hence the marked change of experience consequent on established facility.

In this way also actions become associated or related, so that they naturally attend upon each other. There is an actual nerve relation established between the co-operating lines of nerves. Every one has noticed how certain movements of the eyebrows or expressions of the face attend upon actions such as playing a wind instrument. Observation of any orchestra will afford illustration. A distinguished cornet or clarionet player may be seen constantly moving his eyebrows while executing a passage requiring considerable effort. The action of the eyebrows contributes nothing to the execution, yet any effort to discontinue this needless muscular movement would disturb the performer greatly. The actions are so co-ordinated, that execution is easy as long as the association is allowed to continue without concern. Effort to break the association would require to be long continued, and would involve no small degree of discomfort. That the association was altogether unintentional makes no difference. Some explanation of the association is found in the two considerations adduced by Müller,[1] that "it is most easy for the will to determine whole groups of muscles to action," and that "a voluntary movement is more difficult the smaller the number of nervous fibres requiring to be excited, and the smaller the part to be moved." This is readily shown by the attempt to move a single finger rather than the whole hand.

There is one thing, however, to be noted, which must have careful consideration hereafter, that the most striking examples to which our attention can be turned are essentially connected with *voluntary action.* The illustrative value of cases would be enormously reduced, if we abstracted everything coming from exercise of volition, and restricted observation to spontaneous nerve action. That the law of increasing facility and efficiency applies to nerve energy and nerve fibre as such, there can be no doubt; but self-direction so wonderfully utilises the law, that we could not properly study the characteristics of the nerve system in man, did we not mark the uniform presence of a voluntary element in all the more striking examples of the increase of conducting power in the sensory and motor nerves.

Beyond this subject arises the question concerning the ratio of intensity in sensation, and the rate of transmission along a sensory and a motor nerve. These questions have engrossed a large amount of attention from Weber, Fechner, Wundt, Helmholtz, Du Bois-Reymond, and others. To enter with any minuteness into the methods and results of inquiry on these points would carry me much beyond the limits I must assign to myself. The questions, besides, are somewhat removed from the main subject of consideration here, and may be touched upon more cursorily.

Concerning the rate of increase of sensation, there is general agreement as to the law which has been recognised as Fechner's law. Increase of sensation does not keep pace with increasing stimulation. But sensation is intensified in such a way that equal increments of sensation correspond to equal relative increments of impression. Thus 1 added to 100 gives the same increase as 2 added to 200, or 3 to 300. Hence, judging by our own experience, we can say, "where the intensity of the sensation increases by equal quantities, the force of stimulation is also increased by relatively equal quantities." Considerable increase of the stimulating force gives only a slight additional intensity of sensation. In its final form the law is, that sensation increases according to the logarithm of the fundamental impression.[1]

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[1] Baly's transl., vol. ii. p. 938.

The next point of interest is the rate of transmission of influence along the nerve line. This question is applicable equally to sensory and motor nerves. It is, however, most readily tested by the action of the sensory nerve, inasmuch as one person can supply the stimulating force, while the other records the experience. Helmholtz, König, and others, have been at special pains to illustrate this, by showing that the stimulus is first applied, and quickly thereafter the person affected gives the signal of his experience. Helmholtz finds that there is diversity in the case of individuals, as may be expected from the greater sensitiveness which some manifest. As the result of a long series of experiments, he concludes that the transmission of sensory impulse is, at the slowest, at the rate of 28 yards per second, at the quickest, 32 yards per second. Professor M'Kendrick has given drawings of the ingenious instrument employed by König for testing the rate of transmission.[2]

From the general view of the functions of the two great orders of nerve fibre, I proceed to consider briefly the nerves of special sense. These, as nerves of sensation, come under the ordinary laws of sensory nerves. They are dependent for healthy action upon contact with the grey matter of the nerve centre. They are distinguished by special terminal organs providing for susceptibility. They are connected indirectly with lines of motor nerves, and have their sensibility considerably affected by this correlation. Touch, taste, and smell are most closely allied with the ordinary sensory nerve. It is indeed true that hearing and sight imply modifications of touch, yet there is in the case of these two a much more remarkable arrangement of terminal organ requisite for the specific action of the nerve line.

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[1] Fechner's *Elemente der Psychophysik*, 1^{ster} Th. 64; 2^{ter} Th. 13. Wundt, *Grundzüge der Physiologischen Psychologie*, 301. M'Kendrick's *Physiology*, p. 544.

[2] *Outlines of Physiology*, p. 538.

The nerves of special sense, as previously remarked, are principally connected with the head, and have thus a close local relation with the brain. Hence they, with the motor nerves which attend on them, are known as cranial or encephalic nerves. In sight, smell, hearing and taste, the terminal organs are dual in form, and hence there is a pair of nerves for each sense. Touch has a multiform arrangement. It is indeed associated with the whole surface of the body, though it is concentrated in special form at the tips of the fingers. As it is the sense most widely related to the nerve system as a whole, it is in reality the typical form of all sense. Wherever there is sense there is sensibility to impression, and that is acted upon by contact in one form or another.

The Olfactory Nerves stand first in the order of cranial nerves, and with smell, therefore, we begin the enumeration of the special senses. The nasal passages have a twofold function to fulfil, for in them we have the entrance of the air passages, for breathing, as well as the distribution of the olfactory nerve. The respiratory arrangement belongs to the floor of the nose, the olfactory to the roof of the nose. This combination is of great value in relation to the sense of smell, for the drawing into the nasal passages of a current of air is an essential thing for discrimination of odours. The upper portion of the nasal passage is covered by a soft mucous membrane, on the surface of which are numerous olfactory cells, which constitute the terminal organ of the olfactory nerve. From each olfactory cell a fibre is sent forward, which, according to Schultze, has a fretted or brush-like appearance. Towards the deeper surface of the membrane another fibre stretches from the cell, more slender in appearance than the fibre at the surface. This fibre is sometimes terminated in a point, sometimes bifurcated, and at other times flattened out. The olfactory nerve fibres are spread out over the membrane in elaborate ramifications, and come into close relation to the olfactory cells. They are gathered together in a series of bundles (enumerations vary from 15 to 20, and even 25 bundles), which terminate in a bulb at the base of the brain. As to excitation, the common opinion is that odorous particles float on the atmosphere, and stimulate the brush-like filaments of the olfactory cells, making an impression which is transmitted to the nerve centre. It cannot be said that these facts have been scientifically established, or that the relations of the olfactory cells and the fibres have been traced, but the analogies of the nerve system favour this view. The bulb in which the olfactory nerves terminate at the base of the brain is of the nature of a special nerve centre, consisting of grey matter as well as of white, and the grey matter contains rounded and pyramidal cells, packed in nerve glue, just as in the brain proper. This bulb is connected by its peduncle and roots to the uncinate and arched convolutions of the brain, which are the proper central endings of the nerve of smell.

Second in order of cranial nerves are the pair of Optic Nerves, proceeding to the organs of vision. These terminal organs, being open to observation, are familiar to all, yet the intricacy of structural arrangement is such that it is difficult to represent to ourselves the unity which is the result of so many combinations. The eyeball is protected in front by the eyelid, which is covered within with soft mucous membrane, which is reflected on the front of the eyeball. Above the orbit is the lachrymal gland, whence comes the tear supply, the fluid passing over the cornea, and being carried off by the lachrymal ducts into the nose, so as to mingle with the mucous secretion of the nostril. The structure of the eyeball will be best illustrated by the aid of figure 16.

The exposed surface of the eyeball (the cornea, *co*), which is convex without, concave within, is translucent. It is lined behind by an elastic membrane not more than $\frac{1}{1200}$th part of an inch in thickness, over which is a soft layer of cells, which are spread round the membrane. The substance of the cornea consists of layers of soft fibres, to the number of about 60, laid one in front of the other, which are closely connected together, with numerous delicate cells dispersed throughout. This body depends for its transparency on the distribution of the fibres. Any derangement of them is apt to interfere with this.[1] Immediately behind this external body is a chamber (*aq*) filled with a clear watery fluid, essential for the translucency of the external portion of the eye. To the rear of this chamber is the lens (L), known as the crystalline lens. This is a solid transparent body, albuminous in nature, and in shape convex on both sides. When broken up, it is found to consist of a solid hard nucleus in the centre, and it is encompassed by a series of layers, which are harder towards the interior, softer as they approach the surface. Converging on the central point of each convex surface are a series of lines, which give a star-like appearance to the front and back of the lens.

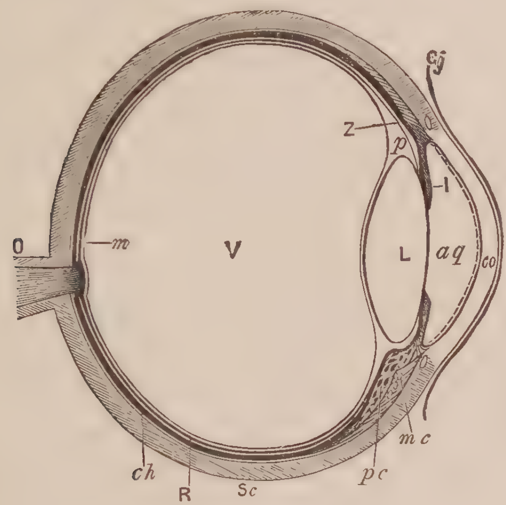

Fig. 16.—STRUCTURE OF THE EYEBALL.

(*From* Turner's *Anatomy.*)

'Diagrammatic section through the eyeball. *cj*, conjunctiva; *co*, cornea; Sc, sclerotic; *ch*, choroid; *pc*, ciliary processes; *mc*, ciliary muscle; O, optic nerve; R, retina; I, iris; *aq*, anterior chamber of aqueous humour; L, lens; V, vitreous body; Z, zonule of Zinn, the ciliary process being removed to show it; *p*, canal of Petit; *m*, macula or yellow spot. The dotted line behind the cornea represents its posterior epithelium."

Between the fluid chamber and the crystalline lens, with an opening in the middle, is the coloured membrane, known as the iris (I), which gives the distinctive colour to the eyes of individuals. This membrane, being muscular, is capable of contraction and expansion, allowing for a continual change in the size of the opening, as the requirements of vision may demand. This opening in the membrane is what we speak of as the pupil of the eye. Around the margin of the opening there is a narrow band of muscular fibre, entwined among which are fibres radiating outwards to the circumference of the membrane. By means of these fibres, the iris regulates the size of the pupil, and the amount of light transmitted through the lens. Another small muscle, the ciliary muscle (*pc*), surrounds the outer margin of the lens, on which it acts so as to modify the curvature of its anterior surface, and adapt the eye to the vision of both near and distant objects.

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[1] Quain's *Anatomy*, vol. ii. p. 715.

Behind all the parts already described is the vitreous body (V), which is by far the largest part of the eyeball. It is nearly spherical, but having in front a hollow in which the lens rests. It is full of fluid, containing salt and albumen, which is enclosed within a thin clear membrane, and is completely transparent. It acts as the support of the retina (R), which is spread over it.

The retina is a delicate membrane, containing the terminal portion of the optic nerve; for it is at this point we first reach the sensory nerve. This membrane is sensitive to light, and is known as the nerve tunic. By Schultze, the retina has been shown to be elaborately constructed, having behind its anterior limiting membrane a layer of nerve fibres,—behind these a layer of nerve cells,—behind these four layers consisting of fusiform nucleated cells with networks of fine fibrils,—and, last of all, a bacillary membrane consisting of rows of bodies, alternately longer and shorter, the longer being like circular rods, the shorter like sharp-pointed cones. This elaborate formation will be best understood by reference to figure 17.

The network of the retina can be easily recognised by a simple experiment. Let any one perforate a card in the centre with an ordinary-sized pin, and, standing near the window or in the open air, keep moving smartly the little aperture in front of the eye. He will thus gradually throw the concentrated light in upon the whole chamber. He will then see the network with a thin obscure space in the centre. The experiment is of the easiest kind, but is apt to weary the organ, if often repeated. Purkinje's experiment by means of a moving candle in an otherwise dark room serves the same purpose. It is described in Müller's *Physiology*.[1] This form of the experiment has the advantage of showing the retina of both eyes at once.

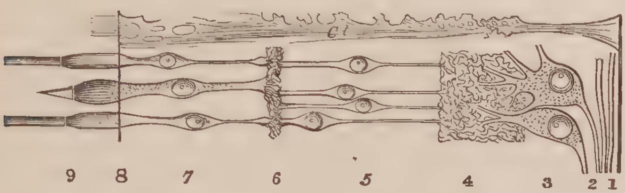

FIG. 17.—STRUCTURE OF THE RETINA.
(*From* Turner's *Anatomy*, modified from Schultze.)

"Diagrammatic antero-posterior section through the retina to show the several layers:— 1. Membrana limitans interna; 2. Layer of optic nerve fibres; 3. Layer of ganglion cells; 4. Internal granulated (molecular) layer; 5. Internal granule layer; 6. External granulated layer; 7. External granule layer; 8. Membrana limitans externa; 9. Bacillary layer, or layer of rods and cones; *Ct*, Connective tissue of the retina."

To proceed, however, with the description of the terminal organ. Just opposite the pupil, and at the centre of the retina, there is a yellow spot about one-twentieth of an inch in length, with a depression in the middle. The yellow colour results from the presence of pigment in the anterior layers. This part is somewhat thicker, except at the depression, and softer than the rest. The nerve fibres are absent from this part, and it is mostly occupied with a series of slender cones packed closely together.[2]

On the inner side of this yellow spot the optic nerve enters the retina, and thence distributes its fibres towards the front border. These fibres are very minute, "the largest of them being only about 1-6000th part of an inch in diameter, whilst the smallest are no more than from 1-30,000th to 1-50,000th of an inch."[3]

Behind the layer of rods and cones is a layer of hexagonal cells containing pigment, and outside this is the choroid coat, which also contains pigment, and carries a large supply of blood-vessels: and outside this again is a thick coat (*the sclerotic*), fibrous in nature, white in colour, and altogether opaque.

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[1] Vol. ii. p. 1163.

[2] Turner's *Anatomy*, p. 340. Carpenter's *Physiology*, p. 696.

[3] Carpenter's *Physiology*, p. 696.

Thus it is obvious that the eyeball, with its translucent structure in front, and its thick opaque coating behind, covering in about four-fifths of the whole, is a camera-obscura. The cornea, convex in front, concave behind,—and the lens, with its double convex surface,—constitute the refracting arrangements, by which the rays of light from an object are directed upon the retina, producing an inverted image of the object, with all the variety of effects which the different rays indicate. These different rays touch the sensitive surface of the retina, the effect being more especially concentrated upon the accumulation of slender cones at the yellow spot. These various effects influence the optic nerve, which is a sensory nerve, subject to all the laws applicable to nerves of this order, while distinguished by special characteristics adapting it to a set of effects produced by the agency of light. Here, therefore, the effects are twofold,—the effect common to all sensory nerves when stimulated, that is, sensibility; and the effects peculiar to nerve stimulated by rays of light brought to a focus through a translucent body. The optic nerve, which is large, firm, and round, takes its course direct for the part of the nerve centre known as the optic commissure, where the nerves from the two eyeballs are joined together, forming a flattened band. These two optic nerves are quite distinct, but each gives off to its companion a series of fibres by means of which they are closely connected. Each optic nerve passes backwards from the commissure, forming the optic tract, which has its central ending chiefly in the optic thalamus and corpora quadrigemina.

In this description the leading facts are included which physiological science has established; and these are concerned exclusively with the structure and working of the mechanism. The explanation of the resultant experience is a matter of great difficulty—a difficulty not yet overcome. Our best course is to mark clearly the different steps by which physiology guides us to the landing-place actually reached. *First*, attention is directed to the arrangement of lenses, the first convex on the outer side, concave on the inner; the second double convex. By the situation of these two, the rays of light are brought to a focus and carried directly to the back wall of the darkened chamber, so that every point of an object is represented by a point in the image traced on the retina. The influence of light thus takes effect upon the tracery of the retina. It has been shown by Professor F. Boll of Rome, and confirmed by Professor W. Kühne of Heidelberg, that this network possesses colouring matter, named by them "sight purple," which, by chemical action under the effect of the light, produces the representation of objects brought within the range of vision.[1] *Secondly*, there is a twofold plan of adjustment connected with the use of the crystalline lens—the one concerned with the use of the iris or screen by which part of the lens is covered, the other with the management of the lens itself, which is capable of being somewhat shifted in relation to the outer transparency. The screen is so fitted as to prevent certain rays striking the sides of the lens; and it can be closed more effectually over the lens, so as to diminish the aperture lying open to the rays. In addition, the lens itself is capable of being acted upon by the ciliary muscle in such a way as to increase its convexity, and so carry its surface forward in closer proximity to the translucent cornea. By this double provision there is the possibility of adjustment to the relative distance of the object of vision. Thus if an object be first seen at a distance, and then rapidly carried towards the observer, the focus can be adapted to its approach. *Thirdly*, there is the possibility of seeing the retina itself, in a manner closely analogous to that by which we see an external object. This circumstance proves, in accordance with the experiments of Boll and Kühne, that the light operates directly upon the sensitive surface. It is thereby shown that the sensitiveness of the retina is the real key to our experience by vision. Müller takes this view of the bearing of the experiment of Purkinje. He says: "We have here a distinct demonstration of the axiom that in vision we perceive merely certain states of the retina, and that the retina itself is the field of vision—dark in the unexcited, illuminated in the excited condition."[2] This view is borne out by the spectra, sometimes coloured, sometimes colourless, we are capable of seeing when the eyelids are closed, after having looked steadily for a time at some bright object. The reality of such spectra is familiarly known by the result of looking at the sun. It is also illustrated by looking steadily at the window for a time, then closing the eyelids, and holding the hand or a handkerchief over them. A luminous representation of the window appears, the cross-bars being at first dark, the panes bright. If there be any obscurity or uncertainty in the representation, it is often sufficient to remove this, merely to raise the hand from the eyes, and gently, though smartly, rub the eyelids with the tips of the fingers. The cross-bars of the window then appear bright, and the panes of glass darker. Additional testimony is gathered from the spectra of coloured objects. These spectra are always coloured, and "their colour is not that of the object, or of the image produced directly by the object, but the opposite or complementary colour."[1] In this way the spectrum of a red object becomes green when the eyelids are thoroughly closed against light. *Fourth*, the yellow spot in the centre of the retina is the specially sensitive part. This yellow spot contains multitudes of the cones of the retina compactly arranged. There is here a difficulty in carrying through the explanation of the action of the organ, because the cones in the yellow spot, or the rods and cones in the other parts of the retina, are not proved to be in anatomical continuity with the fibres of the optic nerve. We can only conjecture that there is communication between the cones and the optic nerve fibres, thereby providing for the impression of light being transmitted to the nerve centre.

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[1] *Nature*, Feb. 1, 1877, vol. xv. p. 296; article by Professor Gamgee.

[2] *Elements of Physiology*, Baly's translation, vol. ii. p. 1163.

Whether the inverted picture on the retina performs any part beyond that of producing distinct impressions according to the varieties of surface represented, may be doubted. Some have supposed that this picture, acting upon the sensitive nerve, is reproduced on the grey matter of the brain. But there is difficulty in assigning to the sensory nerve a power of producing such an effect as copying a pictorial representation of an object, and it is at variance with the recognised functions of the grey matter to suppose that it is a sensitive surface capable of receiving pictorial impressions. If the retina is expressly fitted for this, the cell tissue of the brain is not so fitted, and has other work assigned to it. But, even if it were allowed that the picture produced on the retina is succeeded by a second picture traced on the grey matter, a more serious difficulty lies behind. The grey matter receiving the picture is on this supposition also an active body, endowed with power to see what is traced on its surface. How can we consistently assign two functions so exceedingly dissimilar to the same nerve tissue?

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[1] Müller's *Elements of Physiology*, vol. ii. p. 1183. Brewster's *Optics*, p. 430, § 209.

Connected with this question of communication with the nerve centre, there is a further point arising on account of binocular vision. The two eyeballs, each with its distinct retina, are receiving separate representations, and transmitting separate impressions to the nerve centre. There are in the structure of this organ, as in the organs of smell and hearing, distinct arrangements for securing harmony of action on the part of the two terminal organs, and consequent unity of effect. There is first and specially in the case of vision, co-ordination of motor nerves, which are used in directing the eyes towards the object; and there is harmonious action within each eyeball for adjustment of focus. These arrangements provide for similarity of impression on the retinæ. Next, the two optic nerves are traced back to a point of junction in the nerve centre, where, interlacing to some extent, provision is made for harmony or unity of result, as in the case of sensory nerves proceeding to the opposite hemispheres, yet connected together by lines of communication existing in the nerve centre.

Taking now a survey of what is known concerning the structure and action of that portion of the nerve system devoted to vision, it is plain what constitutes the scientific difficulty. It is to find an answer to the question, What is the relation of the sensitive retina to "the sensorium" or receptive centre in the brain? How does the influence of light on the one produce an effect on the other? Or, as Müller has put it, "the question to be determined is the following: Where is the state of the retina perceived; in the retina itself, or in the brain?" On this perplexity Müller adds: "one of the most difficult problems in physiology is that relative to the respective influence of the retina and sensorium in vision. This department of the physiology of the senses may be correctly styled the metaphysical, since we are at the present time totally destitute of any empirical means of elucidating it."[1] But, this is a purely physiological question, and it must so remain, whether a solution is forthcoming or not, for there is no metaphysical question involved. Psychology can offer no help, for personal experience tells nothing of the transmission of influence from the peripheral extremity of the sensitive nerve to its other extremity in the nerve-centre. Speculative reason does not deal with such a question, whatever may be said for "the scientific uses of the imagination," wisely and eloquently insisted on by Professor Tyndall. We have here an unfinished piece of science. Nothing but persistent scientific inquiry can make up the deficiency. Until this is achieved we must simply own that there are some physiological problems which still baffle our researches. When science proclaims that there is a mystery in this high phase of organic action, it must be allowed so to testify. Philosophy will not interfere, but will patiently wait on science, as in duty bound.

Meanwhile we can but fall back on the general laws of the nerve-system. The optic nerve is confessedly a sensory nerve. It is granted that light acts upon the sensibility of the cones and rods of the retina, and that influence is thence conveyed to the optic nerve. Proceeding on these facts, we must say, in accordance with the general law of nerve action, that movement is transmitted to the nerve centre. From this physiological position we must next pass over into the region of experience, and say that we are conscious of sensation consequent on the influence of light, and at the same time we have a perception of an object. The latter appears the more prominent in our experience, so much so that we recognise less of sensation in the exercise of vision than in the use of any other special sense. In accordance with this, sight is spoken of as "the most intellectual of all the senses."[2] Here the fact that there is by means of the eye sensation of light, is amply illustrated by what has been already said as to the luminous spectra observed when the eyes are closed. This is fully confirmed by the facts which show that the sensation of light can be produced by mechanical, and also by electric stimulation of the optic nerve. I do not here enter upon the grand perplexity belonging to a philosophy of perception as connected with the theory of vision, which would need a treatise to itself, if it were to be discussed. Recognising the special difficulties for mental philosophy which are encountered in the attempt to construct a theory of external perception, I only remark that it is no marvel if psychology has its own share of perplexity, attendant on, and largely caused by, the admitted perplexity of physiological science. While, however, we mark off the boundaries of this unconquered region, it is to be observed that one thing universally admitted—and to be valued accordingly—is this, that there is communication from the external world to the nerve centre, as by all the other special senses. The difficulty connected with a theory of external perception does not involve perplexity as to the existence of an outer world, but is in great measure occasioned by the clearness and fulness of evidence of the fact that individual life is distinct from an outer region of existence. If there be a mystery as to their relations, the distinction of the regions is nevertheless clear. Equally clear is the distinction between the two classes of problems involved. One set is connected with light, its reflection and refraction, the representation on the sensitive surface of the purple-coloured membrane within the eyeball, and the transmission of sensory impulse, together with the relation of motor nerves to the management of the organ upon which the light operates. The other class of problems is connected with personal control of the motor nerves just mentioned, and personal action in the acquisition of knowledge by means of the organ of vision.

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[1] *Physiol. Trans.*, vol. ii. p. 1163.

[2] On the Intellectual Relations of the Special Senses, *v.* Professor Bain's *Senses and Intellect*, pp. 160, 176, 254.

I shall next take the Auditory Nerve, along with the organ of hearing, as another form of special sense calling for more minute description in view of the questions to be afterwards raised. Seventh in order of the cranial nerves is the pair of auditory nerves, connected with their own special terminal organs.

The ear consists of three perfectly distinct divisions, which will be best described by proceeding from the external portion inwards. The following diagram will illustrate their relations and form. The *outer* portion of the ear is irregular, or convoluted in surface. The vibrations or waves of sound falling upon it are reflected, and pass down the passage or canal (*external meatus*), striking from side to side, until they reach a membrane which completely closes the passage, commonly spoken of as the drum of the ear, or, more properly, head of the drum (*membrana tympani*), which is so placed as to incline downwards, or in an oblique direction. Upon this the wave of sound beats. This membrane situated at the end of the outer passage has a concave form, and is consequently convex in the inner cavity or middle ear. It consists of three layers, the outermost of which is a continuation of the skin; the central layer consists of a series of fibres, some of which are arranged as radii, others in a circular manner; the inner-

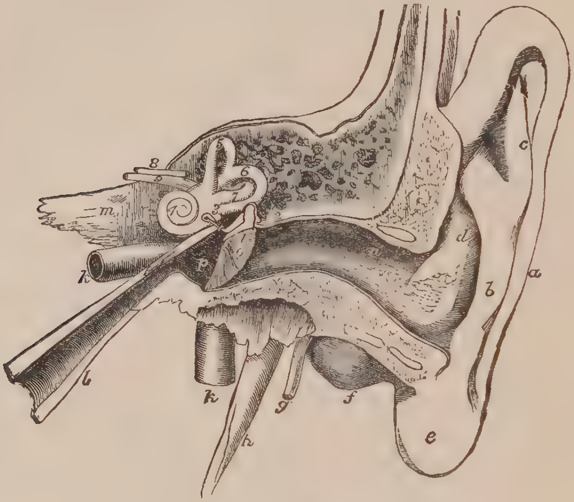

Fig. 18.—THE EAR AS SEEN IN SECTION.

(*From* Turner's *Anatomy.*)

"*a*, helix; *b*, anti-tragus; *c*, anti-helix; *d*, concha; *e*, lobule; *f*, mastoid process; *g*, portio dura; *h*, styloid process; *k*, internal carotid artery; *l*, Eustachian tube; *m*, tip of petrous process; *n*, external auditory meatus; *o*, membrani tympani; *p*, tympanum; **1**, points to malleus; 2, to incus; 3, to stapes; 4, to cochlea; 5, 6, 7, the three semicircular canals; 8 and 9, portio dura and portio mollis. (*After Arnold.*)"

most is a mucous layer, and is a part of the mucous lining of the tympanum.

Just beyond this membrane is a second division of the organ, constituting quite a distinct chamber, known as the drum (*tympanum*), or *middle* ear. This cavity has an opening at its base, which is the entrance of a tube or pipe (*Eustachian tube*), which communicates with the back part of the nose, and is the channel for admission of air into the tympanum. The middle ear is thus a cavity filled with air, upon which the beat made on the drumhead may act, thereby starting in the tympanic chamber a series of wave vibrations. Within this chamber is a series of small bones, placed in contact with each other for the transmission of sound. The first bone has a rounded head, a narrow neck, and an elongated handle below, the end of which is attached to the membrane separating the outer from the middle ear. Its shape has led to its name, the hammer (*malleus*). From this bone a series of ligaments proceeds, by means of which it is securely fastened to the walls of the chamber. The head of the hammer rests on the central bone, known as the anvil (*incus*), which presents a broad surface to it. From the body of the anvil a process passes inwards, and is jointed with the third and smallest of the bones, called, from the peculiarity of its shape, the stirrup (*stapes*). These three bones are so connected together as to form a continuous communicating medium across the chamber of the middle ear, and they move on each other by means of small muscles. The next point of interest here is the inner wall of this chamber. Its special features are grouped opposite to the outer wall formed by the tympanic membrane. More particularly may be noticed an opening of an oval shape, upon which the base of the stirrup bone rests. This opening is protected by a thin membrane, and is named the oval window (*fenestra ovalis*), and this window corresponds with a division of the inner ear named *vestibule.* Below the oval opening is a round-shaped opening, also covered with a thin membrane. This is known as the round window (*fenestra rotunda*), communicating with another division of the inner ear, named the cochlea. The three bones of the tympanum thus constitute a direct line of communication across the chamber, the lower end of the first bone resting on the outer membrane, the base of the third resting on the oval window.

The relations of the three divisions of the organ may be better understood by reference to the following diagrammatic view:—

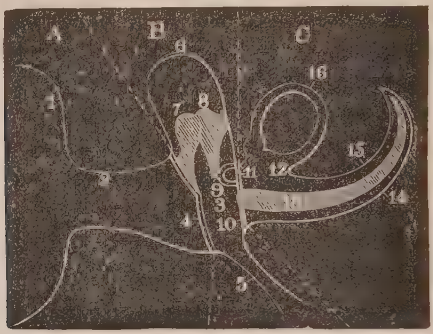

FIG. 19.—THE INTERNAL ARRANGEMENTS OF THE EAR.

(*From* Professor M'Kendrick's *Outlines of Physiology.*)

"Diagrammatic view of the auditory apparatus (*Beaunis*). A, external ear; B, middle ear; C, internal ear; 1, concha; 2, external auditory passage; 3, tympanum; 4, membrana tympani; 5, Eustachian tube; 6, mastoid cells; 7, malleus; 8, incus; 9, stapes; 10, fenestra rotunda; 11, fenestra ovalis; 12, vestibule; 13, cochlea; 14, scala tympani; 15, scala vestibuli; 16, semicircular canal."

We next come to the third division or the inner ear, the innermost recess, in which the extremities of the auditory nerve are distributed. What is found within this chamber may be viewed in two parts, the upper and under, both of which are elaborately constructed. These two parts are respectively connected with the upper and under windows of the middle ear. Immediately to the inner side of the upper or oval window appears the vestibule. As we look towards its upper and back wall, five openings may be seen (fig. 20), which are the ends of three semicircular canals, named the superior, posterior, and external. Two of these canals, the superior and posterior, unite near the vestibule, thereby making one opening suffice for the extremity of two of the canals. This will appear from figure 20, which gives a view of the relations of the semicircular canals, and of the cochlea.

Directing attention first upon the semicircular canals, importance is to be attached to their shape, their internal structure, and their relative position. It will be noticed by reference to the opposite sides of the two vertical canals, that there is an enlarged opening at one end of each. This holds true also of the horizontal canal, though it is not shown in the figure. These enlarged spaces are known as the *ampullæ* of the canals. The outer portion of the canals, as well as of the cochlea opposite to them, is a structure of bone. Inside the canals formed of bone is a membranous structure of similar form, but considerably smaller in size. This membranous structure, though attached on one side, floats in a clear fluid, known as the surrounding lymph (perilymph), and is also filled with fluid, known as the interior lymph (endolymph). "The membranous structure supports numerous minute ramifications of the auditory nerve."[1] So distributed and supported, these ramifications are sensitive to the slightest influence of movement which may occur in this innermost chamber, consequent on the propagation of sound-waves across the tympanic chamber.

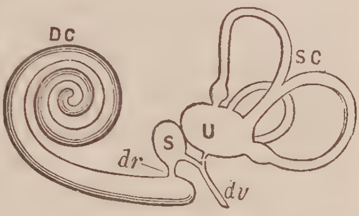

FIG. 20.—THE LABYRINTH OF THE INNERMOST CHAMBER OF THE EAR.

(*From* Turner's *Anatomy.*)

"Diagram of the membranous Labyrinth. DC, ductus cochlearis; *dr*, ductus reuniens; S, sacculus; U, utriculus; *dv*, ductus vestibuli; SC, semicircular canals. (*After Waldeyer.*)"

Besides the auditory impressions produced by sound-waves, it has been observed that the semicircular form of the canals, filled as described, is fitted to secure sensitiveness to a rotatory motion of the body itself. Professor Crum Brown of Edinburgh University directed attention to this in a paper laid before the Royal Society of Edinburgh in 1874, afterwards published in amplified form.[2] Attention had been directed to the same point shortly before, by Professor Mach of Prague, and Dr. Breuer of Vienna. Professor Mach afterwards discussed the whole question in a treatise on the sensations connected with movement,[3] agreeing more fully with Professor Crum Brown than he was at first prepared to do.

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[1] Quain's *Anatomy*, vol. ii. p. 573.

[2] *Jour. of Anat. and Physiol.*, vol. viii. p. 327.

[3] *Grundlinien der Lehre von den Bewegungsempfindungen.*

The internal structure and the relative positions of the semicircular canals clearly fit them for sensitiveness to rotatory motion. When movement begins, the fluid within is at rest, and only gradually becomes affected. As stated by Professor Crum Brown,—"the perilymph lags behind, and thus the membranous canal, which floats in the perilymph, does not immediately follow the motion of the bony canal." But when both come under the influence, "the relative motion of the bony and the membranous canal must produce a pulling or stretching of the forward end of the membranous canal."[1] Some modification of the theory falls to be made on account of the membranous canal being attached to the bony canal. Confirmation of the theory is found, however, in the fact that "when rotation at a uniform angular rate is kept up for some time, the rate appears to the experimenter to be gradually diminishing, and to cease altogether after a time."[2]

The question here arises, how can we in this way be aware of anything more than movement, affecting the sensory nerve? For, as Professor Crum Brown says, "As far as we know, a nerve current can vary only in intensity, and not in kind; so that, if irritated at all, whether by right-handed or by left-handed rotation, the nerve would convey the same message to the central organ;"[3] that is to say, would simply convey an impression of motion, without indication of its direction. This difficulty Professor Brown meets by reference to the ampullae or widened mouths situated at only one end of each semicircular canal, and to the fact that each canal has its own distinct axis relatively to the head or cranium. There is a widened mouth at only one end of each canal, and he supposes that it is only when the perilymph moves inwards from that mouth that the canal becomes a sensitive organ as to rotatory motion. There are three canals in each ear. "In each ear there is one canal (the exterior) in a plane at right angles to the mesial plane, and two other canals (the superior and the posterior) in planes equally inclined to the mesial plane."[4] According to the position of the head as it is moved will be the axis of movement, and in this way the sensibility to rotatory movement will be found sometimes in one canal, sometimes in another. This seems a natural explanation of our sensibility to rotatory motion, though it leaves unexplained the singular and painful experience of giddiness, often felt without any rotatory motion. Hearing is the result of sound-waves in the atmosphere passing into the outer ear, causing movement in the intermediate chamber, and extending the same effect into the innermost chamber, there awakening the sensation of sound; it is, therefore, quite in harmony with the structural and functional characteristics of the organ, to conclude that the canals of the innermost ear should be sensitive to rotatory motion, and that the lymph should, consequent upon movement, act upon certain fibres of that sensory nerve which is organically the auditory nerve. It would hardly follow, however, that we should therefore speak of the effect as a special sense of rotatory motion. Such sensibility must be regarded as one phase of sensitiveness to motion, which is a common feature at other parts, such as the fingers.

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[1] *Proceedings of Royal Soc., Ed.*, 1873-74, p. 256.

[2] *Jour. of Anat. and Physiol.*, vol. viii. p. 328.

[3] *Jour. of Anat. and Physiol.*, vol. viii. p. 330.

[4] *Ib.* p. 331.

Concentrating now, however, on the structure of the ear as bearing on auditory effects, it is needful to direct attention to the vestibule and cochlea. The vestibule, like the semicircular canals, has a bony wall, and in its cavity is the fluid perilymph in which the membranous vestibule is suspended. It will be seen from fig. 20 that the membranous vestibule is in two divisions, the larger (U) being the vestibule to the semicircular canals; the smaller (S) that to the cochlea; and these two are connected by a narrow neck extending from the lower portion of each. From the inner walls of the membranous vestibule slight hair-like fibres spring from cells connected with the auditory nerve. The smaller part of the vestibule is connected with the cochlea. The cochlea is a tubular passage, in shape not unlike the shell of a common snail, wound spirally about a central pillar or modiolus. The narrow end of this body rests against the wall, and occasions a prominence appearing in the intermediate chamber between the two windows. The passage gradually diminishes in area up to the apex. This passage is divided into three spiral chambers, named *scala vestibuli, scala tympani,* and *scala intermedia.* The scala vestibuli and scala tympani contain perilymph continuous with the perilymph of the vestibule and semicircular canals. The scala intermedia contains endolymph continuous with the endolymph within the smaller or cochlear portion of the vestibule (fig. 20, S). The walls of these scalæ are formed partly of bone and partly of membrane, and the membranous wall of the scala intermedia is called the membranous cochlea, which contains numerous terminal branches of the auditory nerve, ending in relation to "a remarkable arrangement of cells, presenting an appearance that has been compared with the key-board of a piano, and has been named the organ of Corti."[1] A series of arches formed by means of rods rises from a broad base, meeting at the key of the arch, where they widen out to a broad head. In connection with these there is a series of conical cells, which throw out a great number of fine hair lines, like tongues of the most delicate tuning forks, liable to be affected by the very slightest vibration of the membranous cochlea, and of its endolymph.

Such is the elaborate structure of the inner chamber, which is filled with fluid as the medium for conveying vibrations through its complicated windings. Throughout its several divisions the terminal arrangement of the auditory nerve is spread, having numerous ganglia, sending out minute nerve fibres; whilst the trunk of the nerve enters the cranial cavity, and ends centrally in masses of grey matter called the acoustic nuclei, situated in the medulla-oblongata. Under these arrangements the ramifications of a sensory nerve are spread out to receive successive impressions. How an impression produces the distinct effect we denominate hearing, it is impossible to tell. But we may conclude that the fluid is set in motion, and begins to circulate through all the recesses, that the vibrations influence the minute hair lines, and that by this means the varied impressions familiar to us are made on the ramifications of the sensory nerve, and are conducted to the central termination. Here, adopting the words of Mr. Lewes, "viewed on the physiological side, is the succession of neural tremors."[2]

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[1] Turner's *Anatomy*, vol. i. p. 370.

[2] *Problems of Life and Mind*, vol. i. p. 119.

In the case of the organ of hearing, the entire structure stands continually open to impression from without. There is no such power of regulation as belongs to the organ of vision. This organ thus presents a problem somewhat different in form from that raised by the organ of vision. Here our main inquiry concerns the interpretation of the impressions which reach the brain from this organ, and of the increased facility gradually attained in discriminating sounds.

Having thus particularly described the terminal arrangements connected with the nerves of smell, sight, and hearing, sufficient materials are at command for dealing with the main question to be discussed, so far as that is illustrated by the special senses. It seems, therefore, unnecessary to describe the arrangements by which provision is made for sensibility of the tongue, or of the surface of the body, or for sensibility in muscular movement. The form of the question to be pressed is in reality the same in all cases, since the uniform provision for sensation is a sensory nerve, with special adaptations at the peripheral extremity, and a central ending in grey matter containing nerve cells at its opposite extremity. The specialities in the modes of sensation are provided for by specialities of terminal organs. The three most remarkable examples have been described in detail. From these descriptions it appears that the terminal organs are analogous to the terminal part of the ordinary sensory nerve. But, in addition to the common characteristic, the special terminal arrangements show minute provision for varied influences and for discrimination of the varieties. Thus there is provision for distinction of odours; of form and colour, and even of slightly differing shades of the same colour; and of sounds, and even variety of tone. It is further obvious, and is to be noted as requiring careful consideration hereafter, that a very large demand is made upon intelligence, if there is to be even an approximation in actual use of the organs, to the possibilities for which they are adapted. And in this connection, as affording further illustration of the demand upon intelligence, it is to be remarked that each one of these terminal organs, by reason of its extreme sensitiveness, is liable to be acted upon by mechanical and other influences different from those for which it is expressly adapted. The ordinary influence must gradually become, in all its ordinary effects, the most familiar. In this way there comes to be a distinction between ordinary and unusual or abnormal experience, the latter being regarded by us as illusory. Hence we have come to speak of the delusions of the senses. There is in reality no delusion. What occurs in a case so described is merely an unfamiliar experience, which we are prone to interpret according to ordinary experience. Doing this, we do, indeed, delude ourselves, though, not unnaturally, we speak of the "delusions of the senses." In this relation, it becomes once more obvious that the organs of special sense make constant and large demands on intelligence for their normal and accurate use.

CHAPTER IV.

LOCALISATION OF FUNCTIONS IN DISTINCT PORTIONS OF THE BRAIN.

THE general characteristics of the nerve system now before us are these,—that the brain includes two hemispheres, distinct from each other, yet closely connected; that throughout all parts of our body there are double lines of communication with the centre, the one set of fibres being sensory, the other motor; and that, as a rule, these two lines cross from the one side of the brain to the opposite side of the body, making the left hemisphere the centre for the right side of the body, and the right hemisphere the centre for the left side of the body.

In attempting to reason from the susceptibilities and activities of the nerve system to the facts of experience, it is obvious that great help must be rendered if it should prove possible by advance of physiology to determine the functions of the several convolutions of the cortex or grey matter of the brain, as we have had determined the functions of the two orders of nerves, with the special functions of the pairs of cranial and of spinal nerves. This question as to the functions of the several divisions of the cortex is accordingly the one upon which the greatest amount of time and labour has for some time been expended by those engaged with investigations concerning the nerve system. This field of research had been clearly indicated by the previous stages of discovery. These had been reached by advancing from without towards the centre. First Haller pointed out that the irritability or contractility of muscular fibre does not depend on its nerves.[1] From 1821 to 1835, Charles Bell presented at intervals to the Royal Society the results of his investigations, in which at length he clearly made out the distinction between "nerves of motion and of sensation."[1] Marshall Hall[2] advanced to the determination of reflex action as characteristic of certain portions of the nerve system, in contrast with voluntary action. He showed that, besides voluntary action, there are amongst involuntary actions not only those connected with breathing, nutrition, and the various secretions of the body, but also reflex actions, which are produced by means of a stimulating influence coming from the extremity, and then giving rise to a responsive or reflected activity. In this relation it was shown that the portion of the subordinate nerve centres (*Medulla*) lying nearest to the spinal cord, is of itself a centre for reflex action, irrespective of the action of the Brain Proper. Thus the way was opened for a more deliberate consideration of the functions of the superior divisions of the central organ, and specially of the Brain itself. Through a long series of difficult and delicate investigations, to which references will be made as I proceed, we have been brought at length to a full discussion of the question as to the possibility of localising functions in distinct portions of the brain.

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[1] Haller's *Elementa Physiologiæ*, Lausanne, 1762.

In all countries the attention of skilled physiologists has for a considerable time been directed to this subject. The interest in it was stimulated and guided by pathological observations, more especially those which connected paralysis of certain portions of the body, and so-called "mental diseases," with lesions in the brain, which were disclosed after the death of the sufferers. The homology of brain structure recognised up the whole scale of animal life, and strikingly illustrated by the study of the development of the embryo in different orders of animals, led to a new line of observation in comparative physiology. The question was raised as to analogies of function in the brains of the higher orders of animals, and in the human brain. The use of anæsthetics for relief of suffering under severe surgical operations introduced the possibility of painless operation upon living animals, with the view of ascertaining the laws of functional activity in their brain, thereby guiding to more definite conclusions as to the action of the human brain. Previously, any insight which could be obtained was dependent on rare cases of accident, or the terrible experience of the surgeon and physician in the rear of the battle-field, or in the military hospital near the scene of "action." Cases had from time to time come under observation in which a considerable portion of the skull had been carried away without injury to the brain, and in such cases it was seen that, after nourishment had been given, the flush of an increased blood supply passed over the brain. But of necessity very little insight could be obtained, in such cases, as to the functions of the brain itself.

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[1] *The Nervous System* (collected papers), by Sir Charles Bell, Professor of Surgery, University of Edinburgh.

[2] First in 1832, in a paper on the "Reflex Function of the Medulla," afterwards in a second memoir on "the Excito-motor System of Nerves," and finally in a "New Memoir on the Nervous system" (1843). Dr. Hall was closely followed in support of the same position by Professor Müller of Berlin, *Handbuch der Physiologie*, 1833,—translated by Baly, 1838.

Now, however, we are in possession of a large mass of recorded observations concerning the action of the brain in the case of a variety of animals under the influence of anæsthetics. The circumstance that the nerves can be readily excited by electricity suggested the possibility of experiment on the brain by this agent. For a time it was maintained that the brain is not sensitive to electric influence. But the possibility of electric stimulation has now been clearly established, and amply illustrated. In 1870, Fritsch and Hitzig, as the result of conjoint experiments on the brain of the dog, announced the electric excitability of the brain, and the identification of certain motor areas in the cortex.[1] Fig. 21 illustrates these experiments:—The five points marked were indicated as centres for

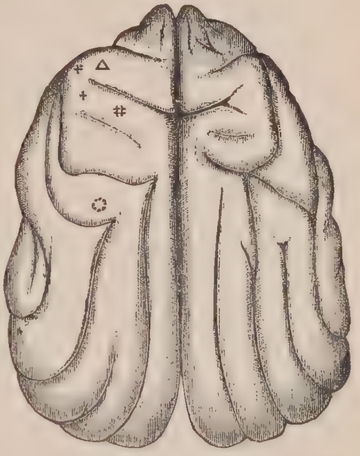

FIG. 21.—UPPER SURFACE OF THE BRAIN OF THE DOG, ILLUSTRATING EXPERIMENTS OF FRITSCH AND HITZIG.

(*From* Ferrier's *Functions of the Brain.*)

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[1] Du Bois-Reymond and Reichert's *Archiv.*, 1870, p. 300.

the following movements :—Δ, Movement of the neck ; ∔, of the fore limb ; +, rotation of limb ; $\substack{++\\++}$, movement of hind leg ; ✿ of muscles of the face.

In 1873 Dr. Ferrier, Professor of Forensic Medicine in King's College, London, submitted the results of a long series of careful experiments on the brains of a considerable variety of animals, by means of which he mapped out the brain to a much larger extent than his predecessors had done.[1] Hitzig prosecuted a further course of experiments, the results of which were published in 1873.[2] The conclusions reached by those investigations were in general harmony, differing only in this, that Ferrier fixed a more numerous set of centres, and often assigned to them a wider area. The accuracy of Ferrier's experiments was keenly contested by a large number of critics, but the result has been a general admission of their reliability, while there continues much diversity of opinion as to the inferences which they warrant. Investigations instituted by a Committee of the New York Society of Neurology and Electrology, which included Drs. Dalton, Arnold, Beard, Flint, and Masson, involving a repetition of experiments from 10 to 40 times, confirmed the conclusions reached by Hitzig and Ferrier.[3] The same result followed from the experiments of MM. Carville and Duret in Paris during the years 1874-5.[4]

By the kindness of Dr. Ferrier I have obtained the use of several of the figures given in his work, which have the areas of stimulation marked upon them. With the aid of these, I shall endeavour to trace in brief outline his investigations as to the localisation of functions in the brain. The problem raised may be stated thus :—Can different functions be localised in distinct portions of the convoluted grey matter of the brain? Or, otherwise expressed, can distinct areas of the cortex be marked out to which distinct functions can be proved to belong? Dr. Ferrier puts the alternative in the following form:—"Whether the cerebrum, as a whole, and in each and every part, contains within itself, in some mysterious manner inexplicable by experimental research, the possibilities of every variety of mental activity, or whether certain parts of the brain have determinate functions."[1] Dr. Ferrier decides in favour of localisation of functions, giving a detailed account of the experiments on which he relies for its vindication. The agency employed by him is the Faradic current of electricity; that is, the interrupted current of an induction-coil, admitting of increase or diminution at pleasure. While referring specially in this relation to electric stimulation, it is needful to bear in mind that nerves may be stimulated by a variety of agents, such as pressure or friction, variations of temperature, and chemical appliances. Experiments by means of chemical stimulation have been made by Nothnagel and others, but the results have not proved so distinct and reliable as those obtained by electric stimulation. Probably the electric stimulus is more nearly analogous to the action of nerve force. Yet the transmission of nerve force along the nerve line is so dependent upon vital relation with the nerve centre, that the transmission is completely interrupted if the nerve line be cut, whereas the cutting of a wire will not hinder the progress of the electric current, if the two ends be placed in contact. Thus experiment by electric stimulation does not imply a complete analogy between the agent employed and the nerve force generated in the brain.

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[1] These results were first published in the *West Riding Asylum Reports*, vol. iii., 1873, and were afterwards given in an independent and elaborated form, *Functions of the Brain*, 1876.

[2] Du Bois-Reymond and Reichert's *Archiv*, 1873, 393.

[3] *New York Medical Journal*, March 1875, p. 225.

[4] *Archives de Physiologie*, 1875, vol. ii. For the history of these experiments and criticisms I am indebted mainly to three very valuable papers in the *Journal of Anatomy and Physiology*, vol. xii., by Dr. W. J. Dodds, prepared when acting as assistant to Professor Rutherford in the Physiological Laboratory of Edinburgh University.

Dr. Ferrier's experiments extend to the brains of fishes, frogs, pigeons, rats, rabbits, guinea-pigs, cats, dogs, jackals, and monkeys. They thus imply tests applicable to a considerable range on the scale of animal life. As, however, it is needful to limit this narrative, I shall restrict attention to results attained in the case of the dog and of the monkey. The mode of experiment is to place the animal under the influence of such an anæsthetic as chloroform; thereafter to expose the surface of the brain; then to apply the electrodes to a point on the brain, noting the effect, and repeating experiments, until it appears beyond doubt that a uniform result has been secured. The brain of the monkey is taken as the test, being allied in structure to the human brain.

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[1] *Functions of the Brain*, p. 124.

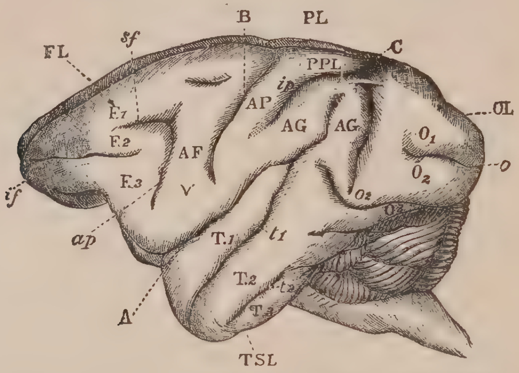

FIG. 22.—BRAIN OF THE MONKEY—LEFT HEMISPHERE (*natural size*).

(*From* Ferrier's *Functions of the Brain.*)

Restricting attention to the single capital letters outside the figure, the four main divisions of this brain are easily seen. *First*, there is the great fissure from below, running upwards with inclination towards the rear, dividing the organ into a front part and a back part. This is marked A, and is known as the Fissure of Sylvius. *Second*, there is the fissure coming from above downwards, showing an inclination towards the Fissure of Sylvius, constituting the right boundary of a frontal division of the brain, and the left boundary of a middle division belonging to the upper region of the brain. This is marked B, and is known as the Fissure of Rolando. *Third*, there is a fissure also coming from above, which terminates the middle division in the upper region, and is the left boundary of the back region. This is marked C, and is named, by combination of the names of the two regions it separates, the Parieto-Occipital Fissure. These three fissures mark out the four great divisions or lobes of the brain;—to the front of the first and second is the Frontal lobe; between the second and third is the

Middle lobe, lying in the upper region, and called the Parietal lobe; behind the third is the posterior lobe, known as the Occipital; and in the lower region, behind the first fissure, is the middle division on the lower side of the organ, which is known as the Temporo-Sphenoidal lobe. There are thus four divisions, one to the front, one to the back, and two in the middle, the one upper, the other lower. Keeping still to the outside of the figure, and taking now the double capitals, the front lobe is marked FL, the back lobe OL, the upper middle PL, the lower middle TSL. These are, as we have already seen, the four lobes of the human brain. The two brains are in very close analogy, with this exception, that the parieto occipital fissure, which is the boundary of the occipital region, is not so marked on the surface of the human brain. The small italics outside the figure indicate minor furrows or sulci in the frontal region, one the superior, *sf;* the other inferior, *if;* and the third anterior to the parietal, *ap.* Similar use is made of small italics within the figure. Within the front lobe, 1, 2, and 3, after F, indicate the upper, middle, and under convolutions; AF, the ascending frontal convolution. In the middle upper lobe (parietal) there are AP the ascending, PPL posterior, and AG the angular Gyrus. The figures 1, 2, 3, after O and T, indicate upper, middle, and lower convolutions in the two remaining lobes. In addition to these four lobes there is in the brain of the monkey, as in the human brain, the central lobe (Island of Reil), covered up by the folds of the Sylvian fissure.

With this map of the brain of the monkey before us, it is manifest that the theory of localisation of functions in the cortex of the brain encounters great preliminary difficulties on account of the unbroken continuity of the several parts of the organ. The various divisions or lobes of the brain are not only in close proximity, but are actually united or continuous. The same thing holds true when we turn attention to the convolutions of each lobe, for in no case is there isolation of one from the others, but in all cases communication. These considerations clearly favour the hypothesis that the organ may in all cases act as a whole, while having undoubtedly its distinct points of established relation with the several parts of the body. There is this additional perplexity for the hypothesis of localisation of function, that inter-communication of all the parts suggests the possibility of diffusion of influence on application of any such stimulating agency as electricity. At the same time, the results of Dr. Ferrier's experiments are sufficiently definite, and have been amply tested. Whatever dispute there may be as to their interpretation, the results themselves are beyond doubt. The nature of these results will appear from the following figure :—

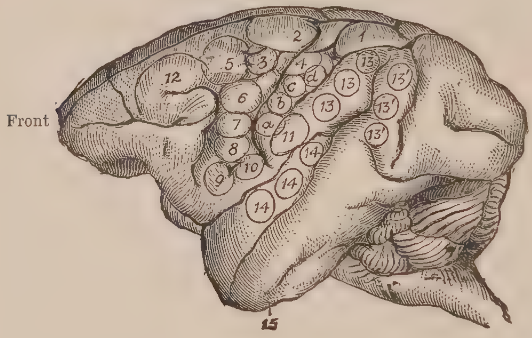

Fig. 23.—BRAIN OF THE MONKEY, LEFT HEMISPHERE, SHOWING CENTRES OF STIMULATION INDICATED BY FERRIER'S EXPERIMENTS.

(*From* Ferrier's *Functions of the Brain.*)

The exact position of several of these centres will be better understood by reference to figure 24 (p. 87), giving the upper surface of the hemispheres.

The first glance at these figures shows that the centres identified are chiefly clustered upon the central portion of the organ. This does not arise from the circumstance that Dr. Ferrier restricted his attention to the area indicated, for his experiments ranged over the entire brain; but the unmarked portions are those which were experimented upon by application of the electrodes without any consequent movement, or evidence of influence being communicated. These unmapped portions of the brain, therefore, raise a distinct problem, which is not likely to prove easy of solution. To this problem I shall turn attention after having given some account of the centres which are marked, and the testimony thereby adduced as to the functions of the brain.

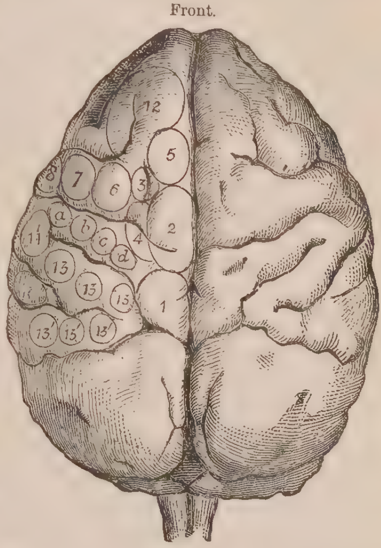

FIG. 24.—UPPER SURFACE OF THE HEMISPHERES OF THE MONKEY.

(From Ferrier's *Functions of the Brain.*)

Instead of taking the numbers in order from 1 to 15 (fig. 23), some advantage will be gained by selecting them in groups, according to the portions of the body influenced.

Interest concentrates first on Nos. 1 and 5. These indicate centres which are both on the summit of the hemisphere, next the longitudinal fissure, the one being towards the back of the brain, the other towards the front. The application of electric stimulation to No. 1 is followed by movement of the hind limb; to No. 5 by movement of the fore limb, each limb set in motion being the one on the opposite side of the body from the hemisphere under observation. The two movements are practically identical, the one being "advance of the opposite hind limb, as in walking;" the other advance of the opposite fore limb, or, as Dr. Ferrier states it, "extension forward of the opposite arm and hand, as if to reach or touch something in front."[1] The account of the second movement seems to embrace more than that of the first. This is readily explained by the consideration that the monkey accomplishes more by the fore paw than by the hind. The observer gives a reference to the purpose of the movement, "to reach or touch," but, as movements merely, the two are the same, the difference being only that in the one case it is a hind limb that is moved, in the other a fore limb. If then the theory of distinct motor centres is accepted, these two circles determine the forward movement of the two limbs on the opposite side of the body. If the theory be doubted, and if only the visible results of actual experiment be accepted, still it is granted that the brain as a whole does, by stimulation at these points, control the movement of the limbs, so as to determine their extension or advance from a present situation to a situation in front. Whether the centres alone exercise the function of determining forward movement in a particular limb of the body, or the whole organ determines such movement by concentrated influence at these points, does not seriously affect the view to be taken of the brain's relations to muscular movements. And as the matter in doubt is one which may prove difficult, or even impossible to settle, it is well to remark the conclusion involved in either alternative. There is so much of the area of the brain directly connected with so much of the muscular system. There are four distinct centres for the motor nerves controlling the arms and legs. And further, it is shown by direct experiment, in harmony with anatomical evidence as to the distribution of the nerve fibres, that each hemisphere is concerned with the control of the nerves which pass to the opposite side of the body. These conclusions drawn from the first examples of electric stimulation here selected will be found to be supported by examples following.

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[1] *Functions of the Brain*, p. 143.

I take next the additional centres concerned with the hind leg and the region of the body closely related. In this group there are included Nos. 2 and 3, which both lie forward from No. 1. No. 2 is a large centre, with a single exception the largest described on the figure. Its proportions will be best seen by looking at the representation of the upper surface of the brain (fig. 24). Its size is in part accounted for by the series of movements attributed to it. These are "complex movements of the thigh, leg, and foot, with adapted movements of the trunk, by which the foot is brought to the middle line of the body, as when the animal grasps anything with its foot, or scratches its chest or abdomen."[1] The movements are such as to bring into exercise a large number of muscles and nerve fibres; but as these commonly perform their part in union, there is nothing surprising in the circumstance that, after the centre

[1] *Functions of the Brain*, p. 141.

had been determined, subdivision of it had been found impracticable. The same remark applies to the statement made by Dr. Ferrier as to No. 3, which is marked as the centre for "movements of the tail, generally associated with some of the movements described under the last." He says, "I have not been able to dissociate the two from each other completely." Certainly nothing is more familiar in common observation than the movement of the tail of the animal along with the movement of the hind limb. Now if these two centres be admitted as experimentally determined, whether under a theory of localised function, or of general action of the brain, a large part, and organically a very prominent and important part, of the organ, is connected with the complex movements involved in the range of action possible to the hind leg of the monkey. And here it may be needful to remark that the species of monkey operated upon was the Macacque, an order of monkey whose agile movements differ considerably from those of the large apes, such as the orang, chimpanzee, or gorilla. The special feature of the movement, as described by Dr. Ferrier, is this: movement "as when the animal *grasps anything* with its foot." Grasping with the foot, more particularly with the hind foot, as in this case, is not a common exercise with animals. There seems, therefore, reason for considering it something special. It is the exercise which we attribute to our hand, and which we should not think of referring to our foot. It is the movement of the foot of the bird as it alights on a branch, and is well illustrated by the action of the parrot in grasping a gooseberry or a plum in order to eat it. While this is a common use of the foot with the bird, it is otherwise with the quadrupeds, being impossible to many animals, such as the horse or ox; and where it is to some extent possible with quadrupeds, it is restricted to the action of the fore paw, as it expands and closes over an object to be held in position. This is illustrated by the cat and dog, and generally by beasts of prey; but even with them it is not the exercise of the hind foot, except in so far as the action is exemplified in climbing. But climbing involves the action of all the muscles concerned in locomotion, and of all four limbs at once; so that grasping by the hind foot singly can hardly be attributed to any animal except the monkey, which not only is habitually engaged in climbing, but makes large use of the hind paw, while hanging on with the hand or fore paw. The great toe on the hind foot of the monkey always acts the part of a thumb. It fulfils on the foot the function of the thumb in the human hand. The foot of the monkey, therefore, does not in its method of use resemble the foot of man, but rather the hand of man, save that it is naturally turned downwards. In illustration of its action I give the following statement by Francis T. Buckland:—"His great toe takes the office of a thumb, and is of the greatest use to him in holding on to branches during the act of climbing. . . . Watch a monkey go up a pole; you will see he places his hind feet on the surface of the pole at a considerable angle to the body (which his anatomy enables him to do), and thus he ascends."[1] In confirmation of the view that this is an action of the foot peculiar to the monkey, it is striking to find that No. 2 disappears from the figures showing the results of electric stimulation on the brain of the cat, dog, and jackal, while No. 3, concerned with movement of the tail, appears in all.[2] This will be seen by reference to the figures of the brain of the cat and dog (figs. 31 and 32, pp. 132, 134). The facts connected with the two centres here taken together seem to warrant these two conclusions: that any form of activity peculiar to one animal, or to a limited group of animals, in contrast with others, will have a special portion of the brain connected with the regulation of such movement; and when any movement is common to a large series of animals, there will be a common centre for producing the movement which is equally habitual with all. These two conclusions are upheld by experiment, whether the doctrine of localisation of function be accepted or rejected. They are in fact only an extended application of the general conclusion reached while considering the two centres first named; for if there be connected with the nerves and muscles some definite part of the brain, by means of which a distinct movement is accomplished, it will follow that there must be a special portion of the brain for a movement which is peculiar to certain animals. The truth of this is established by the clear and uniform testimony of comparative anatomy and physiology.

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[1] *Curiosities of Natural History;* third series, vol. ii. p. 153.

[2] *Functions,* pp. 149, 152, 154.

There is one additional point connected with the large centre, No. 2, deserving consideration. This centre not only covers part of two convolutions, but in doing so occupies a place in two lobes, being partly in the frontal, and partly in the upper middle (parietal) lobe. By this circumstance we are reminded that there is no real severance of the lobes. Whatever reference may be made to sulci and fissures, as convenient boundary lines for marking certain divisions of the organ, it is needful to have it kept constantly in mind that the grey matter is in reality continuous. That there is significance in the subdivision of the brain into lobes there can be no doubt, but not such as to imply a complete severance of functional activity in the parts.

I take now, as closely connected with some of the conclusions just reached, the results indicated by the letters *a*, *b*, *c*, *d*, placed on the ascending convolution of the upper-middle lobe (parietal), along with results connected with the centres numbered 4 and 5 (fig. 23). The result of application of the electrodes to the points *a*, *b*, *c*, *d*, was found to be "individual and combined movements of the fingers and wrist, ending in clenching of the fist."[1] Dr. Ferrier states that he found it impossible to identify centres for the extension and bending of the separate fingers, though all the movements concerned in grasping objects were produced by excitation of these centres. The movements were those of the arm on the opposite side of the body. Experiment on the centre marked No. 4 was followed by movement of the opposite arm, which was first thrown forward, and then brought back again, "the palm of the hand being directed backwards," in a manner "resembling a swimming movement." The centre, No. 5, when stimulated, occasioned "extension forward of the opposite arm and hand, as if to reach or touch something in front." Looking now at the centres Nos. 4 and 5, along with those marked *a*, *b*, *c*, *d*, it is obvious that these six are closely connected. No. 5 provides for the forward movement of the right arm; No. 4 for the drawing back of the same arm; while the centres *a*, *b*, *c*, *d*, collectively, provide for action from the wrist forwards, that is, movement of the whole hand and of the several fingers. In most cases, when the centres *a, b, c, d* are in action, the centres, Nos. 5 and 4, will also be in action, for the arm is commonly thrown forward when anything is to be grasped, whether an article of food or a branch overhead,[1] and it is drawn back again with the food or when the branch is let go. In the close relation of Nos. 5 and 4 with the centres *a, b, c, d,* we have a further illustration of the fact that several centres must very commonly act together. In this fact there may appear something to favour the view that the brain acts as a whole, concentrating its energy on definite points according to the nature of the physical exercise accomplished. When it is further noticed that No. 4 like No. 2 extends over part of two lobes, being partly in the frontal lobe, partly in the upper-middle (parietal), there seems to be additional evidence favouring the conclusion that the brain acts as a whole. Leaving this, however, to remain one of the unsettled points, the clear result of these experiments is that different centres frequently act in unison (*vide* p. 57).

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[1] *Functions*, p. 143.

It seems singular that the centre for the movement of the tail, No. 3, should be found between 5 and 4. In the differently arranged convolutions of the dog, No. 3 stands quite clear of 4 and 5. As, however, in the human brain, No. 3 falls out, Nos. 4 and 5 may be contiguous, and each have more space.

The chief interest at this point, however, gathers around the centres marked *a, b, c, d,* which together occupy almost an entire convolution of the upper-middle lobe. These, as the centres concerned with the movement of the hand, and several joints of the fingers, must be peculiar to the monkey among the lower animals, as the monkey tribe is the only one having a hand with jointed fingers, analogous to the hand of man. Accordingly these centres are wanting in the brain of the cat, the dog, and the jackal, as experimented upon by Dr. Ferrier, with this exception that in the cat (fig. 31, p. 132) there is the first of the series marked (*a*), which indicates the clutching or closing of the paw, as when the cat plays with a mouse. As the joints, muscles, and nerves in the hand and fingers of the monkey make provision for a great variety of movements which are altogether impossible when the terminal organ is simpler in structure, there must be a proportionally greater number of connecting lines between the extremity and the nerve centre than can exist in the brain of lower forms of animal life. The possibility of exciting these centres by electric stimulation, so as to induce movement of all the joints of the fingers, illustrates the truth, clearly implied in the results of anatomical science, that each mechanical provision for movement is connected with a distinct part of the nerve centre. The impossibility of finding any such centres in the brain of other animals was inevitable on the hypothesis. The speciality in the brain of the cat is confirmatory of the inference from the brain of the monkey. The general conclusion to which we are here guided is that the brain becomes more complex in arrangement proportionately to the mechanical complexity of the body which it governs. Comparing together the experiments on the brain of the monkey, jackal, dog, and cat, there are in all four cases definite centres, numbered 5 and 4, for the common movements forward and backward of the fore limb on the right side of the body. But in the brain of the monkey there are special centres (*a, b, c, d*,) for the movement of the fingers, as well as the hand, which are not to be found in the brain of the other animals named.

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[1] There is humour in the suggestion that the monkey should be regarded as intellectually equal with man, because it is educated in "the higher branches."

In order to complete the views of analogy and difference thus obtained, there is one element in the description of the movement resulting from stimulation of the common centre, No. 4, which deserves consideration. Besides the drawing back of the opposite arm, Dr. Ferrier remarks that the backward movement of the arm was effected with the palm of the hand turned backwards, the action "resembling a swimming movement." This is in more obvious analogy with the human hand, and suggests a contrast with the act of dropping the hand when the grasp of an object is relaxed, or the bringing back of the hand when it is full. But it more resembles a purposive movement, such as the latter, than a mere cessation of exertion as in the former. The stimulation seems to have resulted in an action for a definite end. The movement is of the kind which would be executed if the right hand were swept back to take hold of a branch somewhat below, while the left was thrown forward to catch one overhead. If when accomplished under electric stimulation this movement of the right hand suggests the act of swimming, it is to be remarked, as bearing on the analogies of movement, that the progress of the animal from tree to tree, by aid of the swaying branches, must be analogous to an act of swimming. The movement involved is not one of relaxation, but of tension for a definite end.

The centre marked No. 6 when stimulated led to bending of the arm, and elevation of the hand to the mouth. This is a motion familiar with the monkey, so that the communication between the brain and the arm for this movement must be nearly as well established as the communication for ordinary exercise in walking in the case of the dog. The monkey clutches its food in its forepaws, and so brings it to its mouth. The act of the dog in eating is entirely different, involving sometimes only lapping with the tongue, at other times clutching its food so as to hold it firmly on the ground, while the head is lowered, that the teeth may tear flesh or crush a bone. It is, therefore, a confirmation of the conclusion already adduced, when we find that no place in the brain of the dog can be assigned to No. 6 on the brain of the monkey. There may naturally be some surprise that it has not been found on the brain of the cat, since we are all familiar with that movement of the cat's paw when it is engaged "washing its face," as is said. But the movement so described is so analogous to other movements common with the cat, that what we are in search of here may be nothing more than an adaptation of No. 5, under the influence of a special phase of sensibility.

The next group of centres includes Nos. 7, 8, 9, 10, 11. These are situated partly on the frontal lobe, partly on the upper middle, a combination which is confirmatory of what has already been said as to co-operation of different lobes of the brain. These five centres are all concerned with movements of the mouth. Electric excitation of No. 7 leads to action of the muscles of the face, so as to draw back and elevate the angle of the mouth; No. 8 elevation of the outer wall of the nose and of the upper lip, with depression of under lip, thus exposing the teeth; 9 and 10 opening of the mouth, the former involving the act of protruding the tongue, the latter the act of withdrawing it; 11, "retraction of the opposite angle of the mouth."

No. 12 is a large centre quite to the front of the brain, and covering a portion of the two upper divisions of the frontal lobe. This is concerned with the movement of the eyes and head; while away towards the back portion of the upper-middle lobe are situated the six centres numbered 13 and 13′, the whole of which are concerned with the movements of the eyes. Under electric excitation, No. 12, situated far forward, occasions a complex order of movements; "the eyes open widely, the pupils dilate, the head and eyes turn towards the opposite side." When the three centres numbered 13 are stimulated, there is movement of the eyes towards the opposite side, with an upward direction; when the influence is directed on any one of the three centres numbered 13′, there is movement of the eyes towards the opposite side, with a downward direction. With stimulus of any one of these centres, the pupil contracts, and there is a tendency to close the eyelid, as if under a strong light. The wide separation of the large centre numbered 12, from the six centres numbered 13, while all are closely related in respect of the results of their action, is one of the features presented by these experiments deserving special consideration, as appearing to favour the conclusion that there is within the organ a most elaborate system for combining different portions of the brain. In this case, either there is evidence to favour the opinion that the brain acts as a whole, for we must conclude that 12 and the series marked 13 must often co-operate; or if the whole brain is not concerned in the combination of these movements, a large number of related parts act in unison.

A further example of associated action is given by stimulation of the centre numbered 14, the situation of which carries our attention for the first time to the lower-middle lobe (temporo-sphenoidal). This when stimulated leads primarily to "pricking of the opposite ear," but this is combined with turning of the head and eyes to the opposite side, while the pupils are widely dilated. The combination involved in the action of this centre clearly points to a movement of the ear consequent upon some impression made through the eye, and probably conjointly with an impression made upon the ear. If this explanation of the action be regarded as the natural one, this portion of the experiments proves that a wide area is involved in united action.

The centre numbered 15 carries the attention to a region altogether apart from that on which the preceding centres have been found to gather. This is situated quite on the lower portion of the under-middle lobe (temporo-sphenoidal), just as it turns towards the base of the brain. This centre, concerned as it is with the nose, has some degree of association with No. 8. When the electrode is applied to No. 15, there is a twisting of "the lip and nostril *on the same side*." This movement so affects the organ of smell, "as to cause a partial closure of the nostril, as when a pungent odour is applied."[1] Exactly similar results are obtained by experiment upon the same spot in the brain of the dog, cat, and rabbit. The apparent association between the movements produced and the influence of a powerful odour is confirmed by direct external experiment, showing that the movement here produced is beyond question excito-motor. "Similar reaction is produced by the direct application to the nostril of a powerful or disagreeable odour."[2] The reflex nature of this movement being thus determined, the situation of the centre by stimulation of which it is produced is matter of great interest, when we take into account the fact that an analogous centre is found in the dog, cat, and rabbit. In these three animals the olfactory nerve, with large olfactory bulb in front of the brain, is conspicuous. Illustration of this will be found by reference to the three appropriate figures in next chapter, pp. 130-134. Now this centre, No. 15, severed as it is from the other centres which cluster much higher up, is situated in close connection with the olfactory tract. In this way, it presents an important illustration of close local relation within the brain of the parts which provide for sensibility, and consequent reflex activity. This circumstance in itself affords strong confirmatory testimony in support of the whole series of experiments. Additional evidence for the accuracy of the connection indicated between the centres in the brain and the portions of the body controlled by them, is found in the one fact that each branch of the olfactory tract runs directly to its centre on the same side of the brain, and does not cross to the other hemisphere, taken with this other fact, that the result of stimulation of centre 15 in the left hemisphere was visible in the movement of the nostril on the *same side.* This is at once seen by comparing the record as to this centre in the brain of the dog,[1] and on that of the cat,[2] with that of the monkey here adduced.[3] In the case of the rabbit, excitement of 15 on the left hemisphere commonly produced twisting of the nostrils *on both sides.*[4] But the brain of the rabbit is a smooth one, without convolutions, and the olfactory tract is relatively larger in proportion to the brain. It seems, therefore, the more likely that a strong impression made on a point in one side of the brain would induce action in both nostrils, on account of the close union subsisting between the two centres connected with the organ of smell in a brain of simple construction such as that of the rabbit.

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[1] *Functions*, p. 144.

[2] *Ib.* p. 184.

Having now taken a survey of the several centres definitely marked on the brain of the monkey, it is desirable, while reserving details, to notice two general conclusions to which these experiments appear to point.

First. Under these experiments there is a large part of the surface of the brain appropriated for the movements effected by portions of the body. If the eye run along the surface of the brain (fig. 24, p. 87), taking in the following, 1, 2, 5, thereafter going down to 6, next turning back to take 4, and thereafter pass down to include *d, c, b, a*—all these are involved in the movements of the hind and fore limbs on the right side of the body. If next, turning to the side view of the same hemisphere (fig. 23, p. 86), we begin with 7, go down past 8 and 9 on the ascending frontal lobe, and turn up to include 10 and 11, by which we are brought to nearly the same level from which we started on the ascending region of the upper-middle lobe, we find all this division is appropriated for movements of the mouth and tongue. Again, in seeking for movements connected with the use of the eyes, we include 12 (13, 13, 13) (13′, 13′, 13′). Some limitation of these areas, it may be allowed, may yet prove needful under the possible rectification of persistent experiment; but even if this prove true, to the extent of a considerable modification, a high degree of importance must attach to the general observation here adduced.

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[1] *Functions,* p. 151. [2] *Ib.* p. 156. [3] *Ib.* p. 144. [4] *Ib.* p. 158.

Second. The large unappropriated area in no way diminishes the effect of the observation just made, but contributes to its importance. This area embraces considerable portions of the frontal lobe and the under-middle (temporo-sphenoidal), with the whole of the back lobe, and the central lobe or island, hid under the folds of the Sylvian fissure. Still, little short of one-half of the superficial area is appropriated, and this includes much of what is regarded as the most important part of the organ, whether judged by external form or by internal structure. We must consider, besides, how many phases of action are yet to be accounted for by brain control of the muscular system, and also what provision is made at the nerve centre for all the forms of feeling possible through the whole order of sensory nerves. There need not meanwhile be any question raised as to intellectual exercise in addition, because, at the present stage of inquiry, the other elements involved give sufficient importance to the general consideration now before us. Something here will depend upon the ultimate decision as to the interpretation of the centres marked out, whether they are to be regarded as exclusively motor centres, or whether it may be supposed that they are conjointly sensory and motor. The possibilities of modification of result in this way must be carefully allowed for; but even with this proviso, it is impossible to overlook the importance which attaches to the comparative area of the appropriated and unappropriated divisions in the brain of the monkey when placed under electric stimulation.

I shall now shortly consider the results of electric stimulation when applied to the brain of the dog, with the view of comparing results in the two cases. In this way, some test is obtained of the extent to which such stimulation may be regarded as a reliable illustration of brain action; and additional light is thrown upon the wider question of the relations of brain function to the recognised characteristics of various forms of animal life.

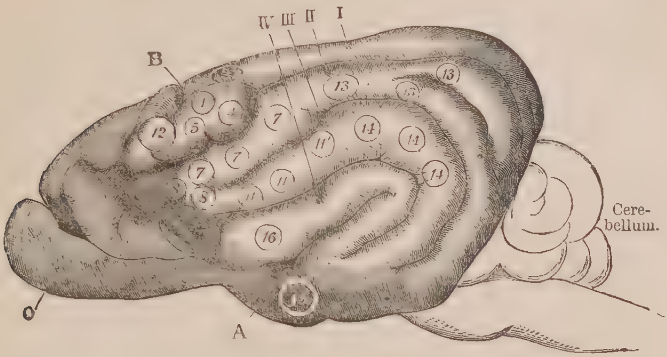

Fig. 25.—BRAIN OF THE DOG—LEFT HEMISPHERE.

(*From* Ferrier's *Functions of the Brain.*

After the detailed account of results given in the former case, it will be unnecessary to enter with the same minuteness upon a description of what may be at once understood by reference to the above figure. In order to facilitate comparison, Dr. Ferrier continues to use the same number to represent the same centre in the various examples selected. It is, therefore, simple to read off his results.

Looking first at the general appearance of this brain, in comparison with that of the monkey, the attention is at once arrested by the addition to the organ, which stretches along underneath, and bulges out in front, marked O. This is the olfactory tract, with large olfactory bulb in front. This indicates that a much larger influence is assigned to the organ of smell in the life of a dog than in the life of a monkey. The next marked feature in the comparison is the difference in the arrangement of the convolutions. They are arranged more in longitudinal form, stretching from front to back, with some additional folds in front. If the eye be directed on the Sylvian fissure, which is the grand dividing line in all convoluted brains, and is marked by the line passing over the olfactory tract from A, it will appear that the convolutions are gathered round this. The substance is first folded on this fissure; next it is doubled back and folded again round the line of the fissure, with a proportionately wider circle; and so a third time, but with some trace of subdivision as it sweeps round at the rear; and again a fourth time, coming from behind and running along the surface. These are the four external convolutions of the dog's brain, marked from above downwards I. II. III. IV. Just where the upper convolution (I.) terminates in front, there appears a second fissure, marked B, known as the crucial or frontal sulcus or fissure. Around this gathers a small group of frontal convolutions.

Comparing now the centres on this brain with those found on the brain of the monkey, I shall take first the analogies, indicating them in the same groups of circles as in the former case. Nos. 1 and 5 were taken as the first group, the former indicating movement of the hind limb on the opposite side, and the latter movement of the fore limb on that side. These are both found here on one of the front foldings, and much more closely together, the one being almost above the other. No. 4 marked the movement in bringing back the fore limb of the right side, and that is here just behind No. 5. No. 3, which marks the centre for movement of the tail, is found here, but to the rear of No. 5, and on the uppermost external convolution. The centres 7, 8, 9, 10, 11 were all found to be concerned with the movements of the mouth and tongue, and they are all here, except 10, the stimulation of which in the monkey's brain was followed by withdrawal of the protruding tongue, but in the case of the dog No. 9 was found to produce the two movements assigned to 9 and 10 in the monkey's brain. Something in this relation may be due to the fact that the dog runs so much with its tongue out, that a larger and more constant measure of nerve energy is directed towards this exercise. This series of centres is here grouped in a manner quite analogous to what was seen in the brain of the monkey, passing round from one convolution to another. The special feature here is that triple centres are found for 7 and 11, and double centres for 8. No. 7 in the monkey is identified as the centre for movement of the muscles belonging to the mouth, and here it is the same. But when the descriptions of resultant actions are compared, it is seen that, in the case of the dog, there is reference to movement of the eyes and closing of the eyelids, as was not done in the case of the monkey. Besides, it is here remarked that both eyeballs are seen to move, while it is the opposite eyelid which closes. All this is in harmony with the recognised habits of the dog, in contrast with those of the monkey. Any one who watches the dog when engaged gnawing a bone, will perceive how naturally he closes his eye while bringing the whole force of bone and muscle to bear on his task. And, as it is impossible for the right side of the mouth to be so engaged without so far exercising the parts on the left side, and both eyes as a rule work together, it is natural that both eyeballs be affected in the manner here represented. This contrast between the dog and monkey is confirmatory of what has been already said, that diversity of muscular movement in the case of distinct orders of animals involves diversity in the structure of the brain. From the cause just referred to, a wider range of action is common to all movements belonging to the side of the face in the dog than in the monkey, and by the association of contiguous muscles and nerves it is easy to appreciate the circumstance noticed by Dr. Ferrier in connection with stimulation of centre 11—"On one or two occasions, I have observed *the ear* on the opposite side drawn forwards while the angle of the mouth was retracted" (p. 150).

The centres numbered 12 and 13 in the case of the monkey were those which were found to regulate movements of the eyes; and the action produced by stimulation of the centres thus marked in the brain of the dog are nearly identical. There is an interesting coincidence in the relative situation of the two numbers, 12 and 13, on the two figures. In both cases 12 is found on the frontal region, while 13 is placed quite far back, behind the centres for regulation of the mouth. The actions following from stimulation of 14 and 15 are identical in the two animals, the first being pricking of the opposite ear, the second twisting of the opposite nostril, as if on application of a pungent odour.

The contrast between the two brains, as illustrated by electrical stimulation, is seen *first* in the absence of certain numbers from the figure of the dog's brain. The absent marks are 2, 6, and (*a*, *b*, *c*, *d*). I do not include No. 10, as it has been accounted for as included within 9. There are thus three distinct centres wanting. Indicated by their respective movements, these three represent: *First*, "Complex movements of the thigh, leg, and foot, with adapted movements of the trunk, by which the foot is brought to the middle line of the body, as when the animal grasps anything with its foot, or scratches its chest or abdomen" (No. 2): *Second*, elevation and bending backwards of the fore-arm, "by which the hand is raised towards the mouth" (No. 6): *Third*, "individual and combined movements of the fingers and wrist, ending in clenching of the fist," marked *a*, *b*, *c*, *d*. Interpreting these negative results, we have confirmation of the accuracy of the method employed. The dog does not grasp an object with his hind foot. He does, indeed, raise his foot to the middle line of the body to scratch the part, but this is little more than the repetition of the movement involved in advance of the hind foot, which is accounted for by the centre numbered 1. The dog does not bend back his forepaw, so as to bring anything to his mouth; and he knows nothing of the movement of fingers requisite for clenching the fist. These negative results afford additional illustration of the position, that the structure of the nerve centre is harmonised with the structure of the body. Where nerves, muscles, and joints are, there is, in correlation with them, a centre to provide for their movement by direction of nerve energy on the mechanical arrangements.

The contrast between the two brains is seen, *secondly*, in the presence of certain features in the brain of the dog which are not found in the monkey. These are not indicated by the introduction of any new numbers upon the figure representing the dog's brain, and on this account it is of more consequence to refer to them. As the centres marked are all connected with movements of certain members of the body, and as all the members brought into motion belong to both monkey and dog, there could be no example of absence of one of the centres in either brain, such as would be in the absence of No. 3 (providing for movement of the tail), if the human brain could be mapped out in like manner. As, therefore, there cannot be the addition of a number to mark any peculiarity in forms of action, we need to guard against risk of overlooking such peculiarities. One of these peculiarities brought out in the description already given is the combination of movements of the mouth, muscles of the side, face, and eyes, showing that an association of several centres may be established in any brain because of the peculiar form of action assigned to certain parts of the body. Another peculiarity is connected with No. 9. Stimulation of this leads to common results in both cases, viz., opening of the mouth and movement of the tongue. But in the case of the dog, when this centre was excited by the electric current, the animal was heard to bark. This deserves notice, along with the fact that the result was only occasionally obtained at first, and then the sounds seemed to be somewhat suppressed. Dr. Ferrier's words are: "Occasionally, as described in my first experiments, the stimulation of this region caused also vocalisation, or feeble attempts at barking or growling. In a subsequent experiment this was exhibited in a very striking manner. Each time the electrodes were applied to this region, the animal uttered a loud and distinct bark. To exclude the possibility of mere coincidence, I then stimulated in succession various parts of the exposed hemisphere, producing the characteristic reaction of each centre, but no barking. The reapplication of the electrodes to the mouth centre elicited the barking, and did so invariably several times in succession."[1] Barking is an essential feature in the life of the animal, and if the centre which provides for opening of the mouth can also when stimulated induce the animal to bark, this points towards an established relation or co-ordination of centres in the brain more widely than the experiments otherwise represent. There is external inducement to bark, and this implies that a centre of sensibility must be co-ordinated with the motor centre, just as we find that the centre, No. 15, which induces movement of the nostrils, lies contiguous to the olfactory tract.

Such experiments as those now described are exposed to serious difficulties in execution. Grave injury is done in exposing the brain to view, occasioning loss and diffusion of blood, and disturbance to the whole body. This disturbance is, however, greatly modified by the torpor which is induced under the influence of chloroform or other anæsthetic, but this involves an abnormal condition of the body, thereby introducing a new difficulty. When the brain is exposed and the electrodes applied, there is great probability in favour of diffusion of electric influence by means of the delicate membrane which covers the organ and carries the blood supply to all its parts. Great as these difficulties are, however, and sufficient to account for considerable diversity of result in the earlier stages of investigation, the uniformity and regularity of effect produced in a multitude of cases under many hands, warrant the conclusion that electric stimulation has produced effects analogous to ordinary functional activity. The experiments of Hitzig and Ferrier have been keenly criticised, not from one standpoint only, but from many, each critic working under influence of the hypothesis most attractive to his own mind. Dr. Dodds has given a valuable summary of the results of these criticisms and experiments, looking at the subject from a physiological, a pathological, and anatomical point of view.[1] The investigations of the New York Committee, of Dr. Burdon-Sanderson, Brown-Séquard, Carville and Duret, Goltz, and others, have been directed to the subject, and whatever differences of opinion otherwise exist, it is granted that the movements described by Ferrier do take place, and that they result from stimulation of the centres as marked. Carville and Duret have given ample confirmatory testimony.[2] The New York Committee of the Society of Neurology and Electrology have shown by experiments repeated at intervals on the same spot from ten to forty times, that the results were easily obtained by application of the electrodes to the centres marked, but that deviation by a very slight degree was sufficient to prevent the result being attained.[3]

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[1] *West Riding Reports*, vol. iii. p. 150.

Alongside the test afforded by repeated experiment, there has been the further test of destruction of the centre, with observations of the consequences in the experience of the animal when recovered from the torpor. Dr. Burdon-Sanderson with a thin knife cut into the grey matter, so as to sever the connection between the superficial area and the part beneath. The part so severed from its organic relation was allowed to remain in position. Under these altered conditions the experiment of electric excitation was repeated, and the same results were produced as before. The incision was next carried deeper, while the severed part was allowed to remain in position. This disturbed the relation with the muscles, and prevented action following. The severed part was then removed from its position, and the electrodes applied to the inner portion of the organ thus exposed. Again the results were obtained as at the first. The process was continued until the band uniting the two hemispheres (*corpus callosum*) was reached, and the active results were again obtained. The incision was at length carried down as far as the motor ganglion at the base of the brain (*corpus striatum*), and there the muscular movements were obtained as at the first, and even with greater distinctness.[1] These results were confirmed by the investigations of Braun[2] and of Putnam,[3] and of Hermann,[4] who adopted a variety of methods.

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[1] *Journal of Anat. and Physiol.* vol. xii. Three articles, pp. 340, 454, 636.

[2] The references, as given by Dr. Dodds, are, *Gazette Médicale de Paris*, Jan. 10, 1874; and *Archives de Physiologie*, 1875, vol. ii. See also *Examen de quelques points de la Physiologie du cerveau*, 1873.

[3] *New York Medical Journal*, March 1875, p. 225.

The question now arises, What significance is to be assigned to the results of incision? If the movements can be obtained after the removal of the grey matter of the brain, what is the inference as to the functions of the grey matter? The first suggestion may be that these later results are unfavourable to the conclusion that distinct functions are localised in fixed areas of the brain. It may be said that Ferrier's experiments show nothing more than this, that there is in the grey matter the power of conducting electric influence to the nerve masses at the base of the brain, and through these to the nerve lines connected with certain muscles. This is the view taken by Hermann. But this view gives no explanation of the possibility of stimulating the grey matter. It is granted that conductivity is characteristic of nerve fibre, and when you have reached such fibres the conducting lines are before you. If electric stimulus be carried along such lines, this is in harmony with the admitted functions of the nerve fibres, and it is a fact which suggests that there is some analogy between nerve energy and electricity. This admitted, there is nothing new suggested in showing that the nerve fibres have power of conductivity. But it is something new and unsupported by evidence to suggest that the grey matter is merely an extension of the conducting lines, in effect continuing these lines to the region of the skull. In view of the structure of the grey matter, it seems impossible to maintain this position.[1] And if so, the results of electric stimulation of the grey matter are unchallenged, while one division of the results—that concerned with conductivity of certain nerve lines to distinct muscles—is confirmed by a second line of experiment. Everything is granted which at this stage the theory of localisation requires. It is admitted that, under the areas marked, the nerve lines are found which are connected with the parts of the body specified. If, then, these nerves are operated upon by application of the electrodes to the grey matter lying directly above the fibres, it follows, either that electricity is so far analogous to nerve energy, that, when the grey matter is thrown into a state of torpor (as in chloroform narcosis), electricity can act through the grey matter upon the nerves; or, electricity is so assimilated to nerve energy, that it acts upon the nerve cells, causing them to discharge their nerve energy down those lines connected with the cells brought under influence. In either case the theory of localisation is upheld. The action of nerve and muscle is effected through the agency of the grey matter; but whether by the isolated action of the area of grey matter operated upon, or by the united action of the whole cortex concentrated upon that area, is not determined.

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[1] *Proceedings of Royal Society of London*, 1873.

[2] Eckhard's *Beiträge zur Anat. und Physiol.*, Band vii.

[3] *Boston Medical and Surgical Journal*, vol. xci.

[4] Pflüger's *Archiv*, Band x.

I am indebted for these references to Dr. George T. Beatson of this University, who, with the late Mr. Stirling, of the Anatomical Museum, assistant to Professor Turner, had given special attention to this subject. The very important anatomical bearings of this whole line of investigation are fully treated by Dr. Dodds—*Journal of Anat. and Physiol.*, vol. xii. p. 454.

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[1] See Dr. Dodds on Localisation, *Journal of Anat. and Physiol.*, vol. xii. p. 458.

The question is now clearly before us, What is the legitimate interpretation of the facts connected with electric stimulation of the grey matter? These facts are such as to suggest some distinctions among the resultant actions. In all cases the stimulating influence has to do with movement of the muscles. But in some cases the relation of the action to what is external to the animal is different from that which appears in other cases. The movements of the limbs, as in running, or as in lifting the hand to the mouth, are different in this respect from the twisting or twitching of the lip and nostril analogous to that witnessed when a pungent odour is applied to the nose. The first class of actions arises more obviously by stimulus from within; the action last named is in appearance a successful imitation of an action which is the result of external stimulus. In the one case the experimenter seems to stand at the source of activity; in the other case, at the turning-point or junction at which an impression from without turns round upon the motor line. This distinction may prove to be one in appearance merely, and not in reality, because an influence from without may operate in the first case, as well as in the last, the difference being merely that the external influence is detected in the one case, and not in the other. The difference does, however, appear, and thus presents the distinction between sensory and motor nerves, and also the contrast between direct and reflex actions, suggesting different lines of inquiry as to possible forms of interpretation. This suggestion is the more important in view of the negative results of electric stimulation over the unmarked portions of the brain.

The position to which we are brought is this:—The centres marked and numbered on the surface of the brain may be either purely motor; or sensori-motor, that is, centres which receive sensory impressions, and thereby stimulate movement; or they may be in part the one, and in part the other. Dr. Ferrier has put the point thus:—"The mere fact of motion following stimulation of a given area does not necessarily signify a motor region. The movements may be the result of some conscious modification incapable of being expressed in physiological terms, or they may be reflex, or they may be truly motor in the sense of being caused by excitation of a region in direct connection with the motor parts of the crus cerebri."[1] I am not at present considering the possibility of the first of the three alternatives; but altogether reserve that for a later and distinct stage of this inquiry. No disadvantage can here result from this reservation, for even if there be "conscious modifications incapable of being expressed in physiological terms," these modifications must be in some sense the cause of stimulation, as the experimenter is who directs the electric current; and in that case we have no other alternatives as to classification of movements than these two, purely motor, and sensori-motor. And even with this twofold classification there is need for caution, for it must be observed that we are merely raising the question whether there may not be two classes of centres from which movements are produced. We are asking whether there may not be a motor centre properly so called; that is, a centre from which immediately or directly the muscular movements are produced; the other, a centre of sensibility so connected with a motor centre as to be capable of stimulating the true motor centre, thus being primarily a centre of sensibility, but at the same time mediately and indirectly a centre of activity. This statement of the alternative is sufficient to show that there is and can be but one class of motor centres, embracing exclusively those centres which are directly or immediately in communication with motor nerves. The whole question now before us, therefore, is, whether there may not be centres of sensibility so closely connected with motor centres, that, when stimulated, they inevitably stimulate the motor centre with which they are connected. And this question is raised with the view of guarding us against a too hasty acceptance of the conclusion that the numbered centres are all motor centres properly so called. Yet must it be true that at each numbered circle we are in any case either upon a motor area, or so near it as to be in contact with it. In *all* the examples given there are motor centres reached by electric excitation; whether these motor centres are localised on the superficial area marked, is the point to be determined.

As previously indicated, a twofold classification of the centres is suggested by the results obtained. The distinction is clear in the contrast between No. 1 and No. 15,—the first and last of the centres marked on the brain of the monkey,—the movement of the limb, and the movement of the nostril. In the last case we discover by actual observation, how the movement is induced. The stimulating influence is an external agent applied to the organ of smell. In the first case we do not know how the movement is produced in ordinary life, that is, we do not find that any external agent produces this movement as in the former case. Our ignorance here marks a point from which further inquiry needs to be started. The recognition of this has led to an additional course of investigation. After the centres had been mapped out, and the results of stimulation recorded, destruction of the centres was resorted to, and the consequent injury to animal life was noted, the results being further tested by examination of the brain after death. By this method a distinction was drawn between Sensory Centres and Motor Centres, thereby advancing a stage further the inquiry as to the functions of different parts of the brain. In the manner thus described, Dr. Ferrier, taking the brain of the monkey as the test, reached the following conclusions,—that the centres marked 13 and 13′ (angular gyrus) indicate the centre of vision; those below (in temp. sphen.) marked 14 are the centre of hearing; that the centre still lower (on the lower border of the same lobe) marked 15, is the centre of smell and taste; and that the centre of touch is found in an internal region (hippocampus major), and cannot be marked on the surface. By the same method it was inferred that the other centres were motor centres, inasmuch as their destruction was followed by paralysis of the part previously shown to be in relation with it, and in some instances complete epilepsy ensued.[1] There is little need to go into details as to a whole series of cases, but a single example may be selected from each side in this twofold classification. I take as illustration of the centre of sensibility, those areas marked 13 and 13′, stimulation of which was attended by "movements of the eyeballs, frequently associated with movements of the head to the opposite side, and very often contraction of the pupils."[1] Destruction of the region indicated (angular gyrus) caused "blindness in the opposite eye." But here appears one of the features in such cases which calls for special consideration, as bearing on the relations of the hemispheres. The destruction of this part of the brain, hypothetically the centre of vision, is effected only on one side, that is, the left hemisphere; and in consequence the right eye becomes blind. But the loss of sight in that eye is not permanent if the analogous portion of the brain on the right hemisphere remains uninjured, "compensation rapidly taking place, so that vision is again possible with either as before."[2] In order to test the result, the left eye, as the one likely to be unaffected, was bandaged; the right eye was exposed. The animal "did not flinch when held close to the gas-light;" and did not recognise its companions in the cage. About an hour afterwards the animal was taken out of the cage again, the bandage removed from the left eye, and the animal set down on the floor. "It immediately looked round, and ran nimbly to the cage, and joined its companions."[3] "Next day, however, on the left eye being again bandaged, the animal gave evidence of sight by running up to its cage, the door of which was shut, and lapping water from a dish, which it reached by inserting its hand between the bars."[4] A single day seems to have been sufficient, if, indeed, this may be regarded as the method of recovery, to establish a relation between the right eye and the right hemisphere such as to secure anew the efficiency of the injured eye. In another case the same portions were destroyed on both hemispheres, and the result was total blindness of both eyes. In such a case, Dr. Ferrier says,—"The loss of vision is complete and permanent, so long, at least, as it is possible to maintain the animal under observation." But there is one fact to be specially noted in the example adduced for illustration. "The pupils contracted to light, and light flashed in the eyes caused the animal to wince." Nevertheless the evidence of total blindness was complete. A piece of apple dropped so as to come into contact with the hand was picked up and eaten. A cup of tea was placed to the animal's lips, when it at once began to drink; but when taken from its lips "the animal was unable to find the cup, though its eyes were looking straight towards it." After this test had been repeated several times, the cup was again placed to its lips, when "it plunged in its head, and continued to drink though the cup was gradually lowered, and drawn half-way across the room." On this evidence the conclusion seems warranted that the centres marked 13 and 13′ (angular gyrus) indicate the centre of vision. By similar evidence the centres marked 14 (Superior Temporo-Sphenoidal convol.) indicate the centre of hearing; and the centre marked 15 (lower and inner part of the Temp.-Sphen.) indicates the centre of taste and smell, these two being so closely related that it was found impossible rigidly to distinguish them.[1] If now we combine the two lines of evidence adduced,—the one from electric stimulation, the other from destruction of the centre identified by the former process,—we have a double result. In one sense these centres are motor, that is, these centres are so related to the cells which act upon certain motor nerves, that application of electric excitation induces movement. In another sense they are sensory centres, for destruction of the part is followed by the loss of one or other of the special senses. These two conclusions are established on evidence equally explicit, and both must be kept clearly before us, so that the one be not obscured by regard to the other. There is nothing in the whole course of the observations to throw doubt upon the duality of function at these three centres.

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[1] *Functions*, p. 163.

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[1] See Dr. Dodds on Localisation, *Journ. of Anat. and Physiol.*, vol. xii. p. 458.

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[1] Ferrier's *Functions*, p. 164. [2] *Ib.* [3] *Ib.* p. 165. [4] *Ib.*

In view of the completeness of result which follows destruction of the defined part in both hemispheres, it may be granted that these centres are primarily sensory; but even this position needs to be taken guardedly, and to the extent only of admitting that the actions consequent on electric stimulation are in a sense reflex. If next we inquire as to the motor centre for those actions, the utmost that can be said is that the centres of sensation must have their cells connected by distinct fibres with cells which are functionally related to the motor nerves brought into play. There is nothing in the evidence to lead to the supposition that the motor centres are removed from the circles described, but a great deal to warrant the conclusion that they are included within these circles. More particularly, taking the visual centre as the illustration, it is to be remarked that, notwithstanding the complete loss of vision by destruction of the centre in both hemispheres, there was still sensibility to the action of light, and consequent exercise of motor nerves. "The pupils contracted to light, and light flashed in the eyes caused the animal to wince."[1] Though these eyes were blind, there was still sensitiveness in them; and, consequent on this sensitiveness, reflex action in wincing. We know, indeed, that a nerve retains its sensibility after its connection with the nerve centre has been severed, and even for a considerable time after death has ensued. We are, therefore, not entitled to conclude that such sensibility as that shown after blindness implies a relation of sensory nerves with some other centre than that destroyed. And so, as to the consequent movements, it does not seem perfectly safe to infer that they imply connection with a motor centre somewhere beyond the destroyed area, though it is possible that this may be involved. Further, the results which follow excision of the part, and subsequent electric stimulation of the portion beneath the part removed, as in the experiments of Burdon-Sanderson and others, indicate that the motor nerves are in direct contact with the centre operated upon, and thus they favour the supposition that within the defined circle we have in reality a motor centre, as well as a sensitive. As Dr. Dodds has stated it, "In these cases there is as much reason to believe that the so-called sensory cortex is in part motor, as that the motor region is motor."[2] Dr. Dodds has ably illustrated and supported the position that a sensory centre also contains motor cells, and that a motor centre also contains sensory cells. This is the view which seems most naturally to account for all the facts recorded in connection with the several experiments. For reflex action these things seem needful,—a centripetal or in-carrying nerve, a sensory cell to which the impression may be carried, a connecting fibre placing the sensory cell in connection with the motor cell, and a centrifugal or out-carrying nerve. This is the least amount of mechanism which can provide for the results known. And though there is not direct evidence of the fact, the results of electric stimulation seem to favour the conclusion that the sensory cell and the motor must be in contiguity. If we must in each case suppose not merely a single cell, but a group of cells, the argument for local contiguity will still remain of the same force.

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[1] Ferrier's *Functions*, p. 184.

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[1] Ferrier's *Functions*, p. 165.

[2] *Localisation of Functions*, *Jour. of Anat. and Physiol.*, vol. xii. p. 356.

I proceed now to a single illustration of the bearing of the phenomena of destruction on the centres which are regarded as primarily motor centres. The distinguishing feature of those centres, numbered from 1 to 12, is the apparently purposive nature of the action, resulting from stimulation. The action is obviously adapted to the accomplishment of a particular end. Thus the throwing forward of the limbs, the movement involved in grasping an object, the turning of the head round as if better to observe some object, are actions which are done to accomplish a definite end. And such movements as these result from stimulation of the centres which lie to the front of those already considered. We may further say, that such movements more nearly resemble the class of actions which in our own experience we commonly denominate "voluntary actions." We are, however, still restrained from use of the term "voluntary" or "volitional," as we are not yet in possession of materials by which to indicate its proper meaning. It is, therefore, needful meanwhile to withhold this term, as there are at this stage no data with which to decide what actions are voluntary actions; nor can we have such data until we come to study the facts of personal experience. All use of the term "voluntary" as if it were applicable within the area of physiological observation, is provisional and hypothetical, incapable of definition without passing over into another area, in order to bring thence the needful materials; and, when this has been done, we are without evidence of its applicability within the sphere under observation. It may, indeed, be said that there are two distinct features of the class of actions now under review, both of which have been brought out by electric stimulation, the one negative, the other positive. The one is that we do not find it possible to produce the action by application of some stimulating influence to a sensitive part on the surface of the body, such as the nostril, eye, or foot. The other is that the action is directed towards a definite result. The absence of power on our part needs, however, to be regarded with caution as evidence of something distinctive, for there is nothing in which we are more apt to be misled than in positive inference from negative evidence. The one really definite and trustworthy distinction of the class of actions now under consideration is their manifest adaptation to secure a single end, peculiar to the moment when the action takes place. The end may be the sight of some object, movement towards an object, or grasping an object; but there is some distinct end served by the movement at the moment. Accordingly, the relation of movement and end may be matter of observation. It is to be remarked, however, that in indicating some definite and obvious end as characteristic of these actions, it is neither implied, on the one hand, that reflex actions, such as sneezing or twitching the nostril, have not an end to serve; nor, on the other, that the action, whose immediate end is obvious to us, is done by deliberate purpose on the part of the animal, as when a man walks across the room for a book, or takes up a pen to write a letter.

For illustration of this class of movements, I take the third case given by Dr. Ferrier, as it is restricted to a single centre, and therefore more definite. First, by electric stimulation, No. 6 on the left hemisphere of a monkey was identified as that from which elevation and bending of the right arm was effected. After the centre of grey matter had been destroyed, there was paralysis of the right arm. When this arm was extended, the animal had no power to bend it; and when the animal was lifted, the arm hung loosely by its side, while the other limbs continued under control in the usual manner. This result, applicable to a single centre, presents an example of what was found to hold true when the destruction of the grey matter was resorted to on a wider area. In the case of the dog and cat, complete paralysis does not follow destruction of the centre, but the injury to movement is in accordance with the facts which appear in the case of the monkey. There is thus confirmation of the results attained under electric stimulation, that the centres situated in advance of those previously considered (Nos. 13, 14, and 15), namely, those numbered from 1 to 12, are primarily motor centres. The question which remains undecided is, whether those centres, which are primarily motor centres, may not also be in another phase sensory centres. The special point of interest here is, what answer could be given to the question, Is there any possibility of stimulating these motor centres by acting upon any portion of the surface of the body? Could it be shown, for example, that the muscular sense can exert any stimulating influence over the mechanism of animal locomotion? There is considerable evidence in human experience to suggest such a connection. But we are without direct evidence of this in the facts obtained under electric stimulation, and subsequent destruction of portions of the grey matter.

In absence of direct evidence in any way, and consequent inability to verify reflex activity as characteristic of the movements, it has been suggested that the motor centres may be taken as centres of voluntary motion. But this suggestion labours under the same disadvantage as the other, in so far as the absence of distinct evidence is concerned. Such experiment as that adopted for ascertaining localisation of function in the brain could not possibly afford testimony on such a question. An animal rendered insensible by chloroform,—abnormally torpid,—could not exercise voluntary control, even if such control were possible to it in its normal condition. On the other hand, when the animal is in its normal condition, we can have no evidence of the action of will. For evidence of the action of a power of will we are dependent altogether upon the facts of personal experience. Something more, however, than mere reflex action seems to be involved in those actions of the monkey, dog, and cat, which are observed when the animals are under the influence of chloroform, and when the motor centres are stimulated. But whether this is, after all, a more complex process of sensori-motor activity, or a case of voluntary action, there is no evidence to decide. Dr. Dodds suggests here that "the only probable explanation appears to be that the cells of this motor region of Ferrier form, as it were, the motor alphabet of the will. In a way as yet not understood, the will is able to decide upon certain movements and then, compositor-like, to pick up the areas by whose stimulation the desired result is accomplished. This is rather a loose way of expressing one's-self, but the present uncertainty as to the physiological equivalent of will and its mode of action must be our excuse."[1] That this may be a probable explanation I am prepared to allow; that it is the only possible or probable explanation can hardly be maintained in view of what is known as to reflex actions. When we come to analyse human experience, it will be possible to speak more definitely of Will and its part in the determination of muscular movements. When we advance to that fuller knowledge which personal experience gives, including the deliberations and decisions which precede physical exertion, we may more readily grant that such centres as those now under consideration may constitute a kind of mechanical alphabet capable somehow of being employed by intelligence and will. But when the facts of human experience are referred to, and used as aids to fill up what is lacking in physiological observation, we must at the same time remember how vastly our knowledge of the range of reflex action is widened by these facts. I refer specially here to the well-known circumstance that actions which at first are performed with difficulty, requiring constant attention and self-directed effort for their performance, become so simple that they are done without any conscious effort. They do in fact become in a large measure reflex. In view of this fact, there appears to be need for great caution before we assent to a general statement of the possible range of reflex action. Besides, if we take into account the need for recognising a doctrine of "unconscious cerebration," as developed by Laycock and Carpenter,[2] and now generally recognised, though it may be with co-operation of conscious activity,[3] additional reason is afforded for caution in our conclusions as to the action of the motor centres in animal life. More expressly, it must be kept in view, when it is said that "the will is able to decide upon certain movements," that the language is that of human experience, and that we are without evidence of its being applicable beyond this area.

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[1] *Localisation of Functions, etc., Journal of Anatomy and Physiology*, vol. xii. p. 357.

[2] Laycock's *Mind and Body*, vol. ii. p. 465; Carpenter's *Human Physiology*, p. 647, 7th ed.; Carpenter's *Mental Physiology*, p. 515.

[3] *Vide* Dr. Ireland's paper, "Can Unconscious Cerebration be proved?"—*Journal of Mental Science*, October 1875.

In estimating the results of electric stimulation of the grey matter of the brain, I have now briefly to consider the facts bearing upon those portions which remain unmarked. These are the "silent portions" of the brain, or portions which under stimulation yield "negative results." Described generally, they are the anterior portion of the frontal lobe, the back portion of the brain, or occipital lobe, and the concealed central lobe, or Island of Reil. Repeated application of the electrodes to these parts has altogether failed to call forth any response. This absence of result is remarked in the case of all animals subjected to test; and the portions of the brain which remain silent are analogous. Over the central portion of the organ, both in its upper and under division, response is promptly given, but the front region and the back give no sign. This fact introduces a serious perplexity, on which as yet but little light is thrown by those who have devoted themselves to this line of research. On the other hand, uniformity of result in so many cases is suggestive of some general conclusion as to brain function.

In the circumstances, our first resort must be to anatomical science, in so far as it may indicate the direction of nerves, as connected with the several portions of the brain.[1] Our attention is thus turned on the nerve tracts (cerebral peduncles), which pass up towards the nerve masses or ganglia (*corpus striatum* and *optic thalamus*), lying at the base of the brain proper; and from these to the distribution of the nerve fibres to the grey matter, constituting by their radiation the gathering known as the crown (*corona radiata*). Now, the two large basal masses or ganglia are generally admitted to be distinguishable by the class of nerves which is most prominent in each.[2] The one (*corpus striatum*) occupying the front and outermost situation, twofold in form, is made up largely of *motor* nerves, with some small admixture of sensory. The other (*optic thalamus*) lying behind the former, and also twofold in shape, is composed mainly of *sensory* nerves, with some small share of motor. Of the two large bands of fibre seen above the bridge, we find one bending towards the left, the other towards the right (*crura cerebri*). The superficial portion (*crusta*) of these two bands passes into that ganglion which is regarded as chiefly *motor* (*corpus striatum*), forming in it what is called the *inner capsule;* the deeper portion (*tegmentum*) into that ganglion recognised as chiefly sensory (*optic thalamus*).[1] Thus we have a general distinction between motor and sensory nerves, the one class concentrated in the frontal mass, the other on the mass which lies in the interior. We next turn to the fibres which make up these tracts and masses. Here there is a considerable degree of complexity. If, however, attention be directed mainly on the parts of the brain about which we are now inquiring, viz., the frontal, parietal, and occipital lobes, we shall find a clew. The way is further cleared by noticing that several of the fibres of both the outer and the inner portion (*crusta* and *tegmentum*) of the nerve tracts *terminate* in the masses at the base of the brain. With these, therefore, we are not here concerned. Other fibres of both portions pass directly through to the grey matter. And while fibres terminate in the masses at the base of the brain, new fibres start from these masses. I shall take first the course of the outer or motor portion (*crusta*) of the tracts. The fibres of this division which form the inner capsule pass directly up to the grey matter of the *back lobe* (occipital), and to the under-middle. Mingled with these fibres are others which originate from the basal mass (*corpus striatum*). Together they form the more anterior part of the *corona radiata,* a large number of the fibres of which go to the grey matter of the *frontal lobe,* to end in the convolutions of that lobe in proximity to the fissure of Rolando. It will be remembered that it is in these convolutions that the giant pyramidal cells of Betz are arranged in clusters, and that it is in these parts that the motor areas of Ferrier are localised. Here then we have *motor* nerves traced to all the three silent parts of the grey matter, but the larger number are directed towards the front. Tracing now the course of the deeper or sensory portion (*tegmentum*) of the tracts, the fibres of this pass up to the inner mass (*optic thalamus*) at the base of the brain, where they largely terminate. But from the grey matter of this basal mass arise a great many radiating fibres which pass up to the grey matter of the brain in all its lobes. Those from its posterior part go to the *back lobe* (occipital), and to the under-middle, becoming associated with the nerves of special sense, sight, and smell, which take this course; those from its anterior part go to both the under and upper middle lobes, and to the *frontal lobe* and the *island*. Thus again we have *sensory* nerves traced to all the three silent portions of the grey matter. I shall only briefly state the conclusions which seem warranted by these data. *First*, motor and sensory nerves go together to all divisions of the brain; to those which are silent under electric stimulation, as well as to those which respond. On anatomical grounds, it seems warrantable to maintain that all the five lobes must be sensori-motor; and, if the theory of definite centres in the grey matter, with special functions, be accepted, both sensory centres and motor centres must be found in all the lobes. *Second*, There is a preponderance of sensory nerves to the back region of the brain (occipital lobe), and a preponderance of motor nerves to the frontal region. These are the two conclusions which may be regarded as fairly well ascertained since the investigations of Meynert and others were specially directed upon the distribution of the nerve fibres to the grey matter of the brain.

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[1] I am here under special obligation to the Third Article of Dr. Dodds—*Journal of Anatomy and Physiology*, vol. xii. p. 636.

[2] See Fig. 11, p. 32.

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[1] Quain's *Anatomy*, vol. ii. p. 538; Turner's *Anatomy*, vol. i. p. 290; Ferrier's *Functions*, p. 236.

These two conclusions seem to me to throw no doubt over the positive results attained by electric stimulation. The history of these results, it will be remembered, was this: *first*, a series of movements was obtained from all the centres marked, apparently suggesting that they were all alike motor; *next*, a distinction was drawn, on the ground of the recognised effects of external stimulus in some cases, thereby making some of the centres primarily sensory in their character, but leaving undisturbed the earlier view that they were at the same time motor centres, subordinated to the sensory; and *lastly*, the remainder were left in their original position as primarily motor centres, but with the acknowledgment that nothing can be done, so far as yet appears, to determine whether these may not be subordinately sensory, as the others are subordinately motor.

Anatomical research clearly favours the view that sensory and motor nerves are distributed together to all the lobes, and to all the convolutions in each. The positive results of electric stimulation must, as I think, be interpreted in view of this fact.

The bearing of the two conclusions just reached, on the "negative results" of attempted stimulation of the frontal and back lobes of the brain, leading to the admission of "silent regions," occasions more perplexity. If it be allowed that electricity acts upon the nerve cells, so as to cause liberation of nerve energy, and consequent nerve action, it would appear to follow that it should do so in all cases. If, by use of this power of stimulation, it has proved possible to distinguish between sensory and motor centres, it would seem certain that the difference between the two classes of centres should introduce no new difficulty. And, if there be sensory and motor nerves in all parts of the cerebrum, it would appear that there should be response from all when placed under stimulation. These considerations must be allowed to occasion serious perplexity as to the silent parts of the brain.

At the same time it must be remembered that it was by an indirect process that sensory centres were distinguished. These centres when stimulated responded *by movements*, just as in the case of the other centres. If then it may be taken as a fact that the single result of electric stimulation is movement, there may be some abatement of perplexity. If there be forms of sensibility which are experienced with little movement of any part of the body, this may so far account for the fact that there is no recognised movement following upon stimulation of the centre even when functional activity occurs. And if experience of sensation be largely dependent on contact with external objects, and not upon visible and separate movement of the part of the body affected, additional force will attach to the consideration now mentioned. Besides, if there be forms of sensation which do naturally give rise to reflex action, as must be held to be the case in many phases of tactile impression, it may be inferred that these are beyond the reach of the method of experiment adopted. These considerations may be regarded as applying more obviously to the back portion of the brain (the occipital lobe), as that more prominently connected with sensory tracts. But this offers little help towards accounting for absence of result in the case of the frontal portion of the brain, which being, so far as anatomical testimony indicates, prominently motor, should most readily respond. It needs, however, to be remarked that the movements obtained by stimulation of the centres confessedly motor are of a very conspicuous order, being movements of the limbs and of external organs easily kept under observation. The centres marked are, moreover, in many cases centres for a large number of co-ordinated movements, thus involving a larger circle as the centre of stimulation, more easily detected and watched, than can be looked for in other cases. It is in fact the most easily observed actions whose centres have been identified. Equally simple and direct identification of activity cannot be anticipated in other cases. But more especially, we have still before us the whole perplexity of self-regulation in animal life, and all that may be involved in what we denominate "intellectual" and "volitional" action. These are the deeper problems waiting treatment which we are only being reminded have not been even touched by the process of experiment. In fact, the results already attained only indicate that the experimenter has broken in upon vital processes at a point somewhere between the origin of activity and the execution of the action, and that he has no power to turn backwards upon the originating force. The results attendant on destruction of the frontal lobes give additional weight to this consideration. Dr. Ferrier reports as to repetition of the test in three different cases, the monkeys operated upon being "selected on account of their intelligent character." In these three cases the entire frontal lobes were removed. After this had been done, the animals "continued to eat and drink heartily, and to exhibit no signs of physical prostration."[1] Besides, "the sensory faculties, sight, hearing, touch, taste, and smell, remain unimpaired;" and "the powers of voluntary motion are retained."[2] But, "instead of, as before, being actively interested in their surroundings, and curiously prying into all that came within the field of their observation, they remained apathetic or dull, or dozed off to sleep, responding only to the sensations and impressions of the moment, or varying their listlessness with restless and purposeless wanderings to and fro."[1] In this description the continuance of "powers of voluntary motion" is apt to appear at variance with some of the other statements, but the phrase may be taken in a loose sense, meaning nothing more than indication of power to move without any external stimulus, or without constraint. And, if this be the meaning, the result in these three cases points to a want of co-ordinated and concentrated activity on the part of the brain as a whole, while loss of the frontal lobe is not found to involve paralysis of motor or sensory nerves.

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[1] *Functions of the Brain*, p. 232.

[2] *Ib.* p. 231.

Definite conclusions reached by aid of electric excitation of the cortex can now be clearly stated.

POSITIVE RESULTS:—(1.) The whole central part of the grey matter of the brain can be brought into functional activity under the electrode; (2.) The effects of electric stimulation are apparent in the more conspicuous movements of the body; (3.) Sensori-motor activity dependent on the special senses can be produced by excitation of motor centres in the brain.

NEGATIVE RESULTS:—The frontal, occipital, and insular regions give no visible response to electric excitation by any manifest action in the organ, or consequent effect on the muscular system.

The conclusions seemingly warranted are these: Motor centres can be directly acted upon by the agency of electricity, but the functional activity of the sensory nerves cannot be produced by application of the electrode to the cortex.

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[1] *Functions of the Brain*, p. 232.

CHAPTER V.

COMPARISON OF THE STRUCTURE AND FUNCTIONS OF BRAIN IN LOWER AND HIGHER FORMS OF ANIMAL LIFE.

WHILE attention was being turned to the results of electric stimulation, some light was thrown upon the difference between the brain of the dog and of the monkey. This comparison of the structure and functions of the brain in different animals is so important as a guide to definite conclusions concerning the specialities of the human brain, that I shall now carry out this comparison on a more extended scale. This I shall do with the aid of figures kindly granted me from Professor Ferrier's *Functions of the Brain*, in which the numbers, so far as they appear, bear the same significance as those already explained in dealing with the brain of the monkey and dog; that is, they indicate "approximate physiological homologies" in the organs. I shall still further extend the range of observation by the use of figures specially prepared for illustration of this department of the subject, in the preparation of which I have been largely indebted to the aid generously afforded me by my colleague Professor Turner.

The order most suitable here is to trace the progression in complexity of structure as we ascend the scale of animal organism. I shall, therefore, begin with the simplest types, and from these advance to the most highly developed.

The simplest form of nerve system is that in which there is only a single ganglion or central knot, into which a few fibres are gathered. This is illustrated in the case of the *Ascidian Mollusk*.[1] This animal has the primary elements of a nerve system, and is accordingly sensitive to contact, and able to expel anything injurious which may be drawn with the water into the mouth. This mollusk is of a pear-like shape, having the mouth at the narrow end, and, not quite half way up the body, a vent through which the water may pass after being sucked in at the mouth. The animal consists of an outer membrane, within which is a muscular envelope, and again within this there is at the narrow end the organ of breathing, at the broader end the stomach. The Ascidian mollusks "are for the most part fixed to one spot, during all save the earliest period of their existence; and they give but little external manifestation of life, beyond the continual entrance and exit of the currents" of water.[1] The nerve centre for this form of animal life is a small ganglion situated between the mouth and the vent. From this centre a few nerve fibres are sent out towards the mouth, a few more pass to the sides in closest proximity to the central organ; and a fibre is sent to the broader end, over which it spreads by means of several ramifications. In this example we have the simplest form of the essential elements of a nerve system, with its centre, and its twofold order of nerves, for there are present the two distinct forms, the sensory and the motor; and accordingly the two distinct functions, sensibility by one tract, and reflex action accomplished by another tract, meeting with the first in the simple central organ.

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[1] Carpenter's *Mental Physiology*, p. 45.

The next stage in the scale is that in which the animal has a head, and within that a pair of ganglia, instead of the single ganglion. This is the first appearance of the twofold formation of the centre, which is thereafter continued up the whole scale. This appearance is coincident with the development of two sides of the body. Thereafter the centre becomes more complex as special organs of sense, sight, hearing, and smell begin to appear along with means of locomotion. The advance in the scale is seen in simplest phase, in the difference between the oyster and the snail, the latter being capable of shooting the head beyond the shell, and in that state directing its movements, which are accomplished by contraction and expansion of the muscular substance. In the head of such animals as the snail there is a pair of ganglia, concerning the structure of which Dr. Carpenter says, "which pair, termed the *cephalic* ganglia, is really made up of several distinct ganglionic centres, and is connected by cords that pass round the œsophagus (passage to the stomach) with other ganglia disposed in various parts of the trunk."[1] Of this class, Dr. Carpenter adds, "Generally speaking, the nervous system bears but a small proportion to the whole mass of the body; and the ganglia which minister to its *general* movements are often small in proportion to those which serve some *special* purpose, such as the actions of respiration."

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[1] Carpenter's *Mental Physiology*, p. 45.

Taking another step in advance, we come upon animals distinguished by the arrangement of joints and adaptation of muscles for a more free and varied exercise of locomotion. This includes insects with legs and wings, and animals with great locomotive power, such as centipedes. In the life of such animals the nervous system is specially concerned with locomotion. As illustrated in the case of the centipede, the nerve system "consists of a chain of ganglia connected by a double cord, commencing in the head and passing backwards through the body. The ganglia, though they usually appear single, are really double, being composed of two equal halves closely united on the median line."[2]

By next stage of advance we come upon vertebrates whose bodily organism is built up on a skeleton of bone, jointed and bound togther with strong ligaments, around which the muscles are gathered, and the whole mechanism is controlled by what is properly denominated brain. It is on this class of animals that interest concentrates for the present. By observation of the lower classes of vertebrates we find the best opportunity for contemplating the simpler and earlier phases of reflex movements.

First I take the brain of a Fish, the carp, which is voracious and swift in movement, being the example.

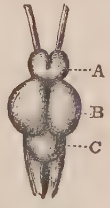

FIG. 26.
BRAIN OF THE CARP
(*natural size*).
(*From* Ferrier's *Functions of the Brain.*)

The projecting lines are the tracts connected with the organ of smell. The frontal lobes (A), which are the hemispheres of the brain, are relatively small when brought into comparison with the optic lobes (B), which here assume the appearance of the chief feature of the entire nerve centre. Just behind these is the cerebellum, assuming a defined and rounded form. From this case it is obvious that special development of portions of the nerve centre occurs in harmony with the development of the special senses, and the amount of exercise assigned to them in animal life. Thus the hemispheres are, in the case of the carp, comparatively small, almost rudimentary, being little more than ganglia, while the optic lobes are expanded to large proportions. The same thing holds true in the brain of the cod, as well as in many classes of the smaller-sized fishes, where swiftness of movement, guided by acuteness of vision, is the chief characteristic. Any one who has watched the habits of fishes, as every angler on a stream is accustomed to do, is well acquainted with the wonderful quickness of vision which they display, making it next to impossible to keep out of their sight when they lie in clear water. On account of this quickness of vision in the fish, most anglers are content to abandon their art when the rivers are clear and small. The more eager of the fraternity betake themselves to the bank of the stream to ply the lure after darkness has set in, fishing patiently and successfully even when they are unable to see the artificial flies they use. Others, who are specially patient devotees of the gentle art, yet reluctant to abandon to the sport the usual hours for slumber, are content, when waters are shallow and clear, to resort to a stooping posture, to accept thankfully the shelter of a well-placed rock, and to throw the longest possible line, by all these expedients to keep alive the hope of some measure of success in the attempt to catch a few fair specimens of the trout or salmon.

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[1] Carpenter's *Mental Physiology*, p. 49.

[2] *Ib.* p. 51.

Wright, a careful observer, and a distinguished aurist, makes the following statements concerning the special senses in fishes:—"With the exceptions I have just mentioned (these are the skate and the whale species) fish possess no external ear or tube to transmit sound," but they "possess the other organisation of the sense of hearing." "Fishes have certainly the senses of smell and taste; the first *very* perfect." "There can be no doubt but they have the sense of sight in great perfection, but some species have it more acutely than others."[1]

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[1] *Fishes and Fishing*, pp. 82, 96, 99.

I take next an example of brain found among the Amphibia, as illustrated by the Frog.

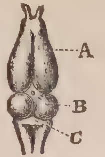

Fig. 27. -BRAIN OF THE FROG (+ 2). (*From* Ferrier's *Functions of the Brain.*)

In this figure the protruding points in front are the tracts connected with the organ of smell; the large frontal portion (A) represents the two hemispheres of the brain, quite smooth, and without trace of convolution; the two round bodies immediately behind are the optic lobes (B), indicating the prominence given to the organs of sight in this form of animal life; just behind these is the cerebellum or little brain (C), appearing only in a small rudimentary form; and immediately behind that is the medulla connected with the spinal cord, which last is in all animals similar in structure. There are here three points deserving special remark: the great importance of the brain as the grand central organ of the nerve system, the greater bulk of the hemispheres towards the rear than towards the front, and the importance assigned to vision as indicated by the relative size of the optic lobes connected with the organs of this sense. In accordance with these features are the known characteristics of the animal, which takes its forward leap by the action of the hind limbs, and is, even in the twilight, singularly quick in vision.

I pass next to Birds, taking the pigeon as the example, on account of it happening to be the bird which has been most under observation of those who have devoted special study to the histology of brain.

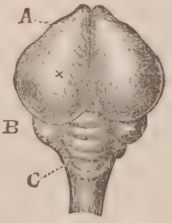

Fig. 28.—BRAIN OF THE PIGEON (*natural*). (*From* Ferrier's *Functions of the Brain.*)

In the following example of the nerve centre, we see the preponderance of the brain proper in the larger proportions of the hemispheres (A) relatively to the other parts. There is at the same time a fuller development of the cerebellum, or little brain C, showing the laminated form, which is its familiar feature as we ascend the scale. In both these respects the brain of the pigeon affords a better illustration than either of the preceding of the normal arrangements and proportions of the several parts. Further, in respect of arrangement, it is to be observed that the optic lobes, the one marked B, and the other in a similar position on the other side, are not seen lying between the brain proper and the little brain, as in former examples; but the cerebrum and cerebellum are brought into close relation, after the analogy of what is recognised higher up the scale. The optic lobes appear as if at a transition period in the course of development,—I might say, appear as if they were on their way for being covered, and concealed underneath, by the fuller development of the cerebrum. If development proceed after the analogy indicated by the three illustrations now before us, we shall have to seek the optic lobes underneath, and not in a conspicuous place within the superficial area of the nerve centre. And this, we know, actually happens as shown when observation is extended up the scale of animal life.

Directing attention now on the special aspects of the brain in the pigeon, as these bear upon the life with which it is connected, there are several points deserving attention. As to the brain proper, it is still a smooth brain, with no trace of convolutions. It does not bear external marks of subdivision, further than is implied in the division into hemispheres; and thus does not suggest the government by its means of a complex organism. Further, though we cannot speak of lobes, it is to be observed that the frontal region is narrow, and that the great mass of the brain is towards the back region. In this respect it stands in direct contrast to the human brain. Next, we must remark the relative insignificance of the olfactory tracts. They do not altogether disappear, their position is still indicated at the front of the hemispheres, but they are not conspicuous as are the projecting tracts seen in the frog and in the fish.[1] This animal is not directed by the organ of smell, as a dominant power in its life, though the sense of smell clearly plays its part. On the other hand, the optic lobes are prominent, and from this fact the natural inference is, that the animal is guided much more by the sense of sight than by smell. At this point we are touching upon a general and well-recognised characteristic of birds, as they sweep through the air, flit from branch to branch, or alight with precision on a slender twig. Within the brain and cerebellum there is power for control of the entire organism and co-ordination of movement on both sides; but vision is the sense which is the true regulating power for all the movements.

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[1] This is well indicated in Professor M'Kendrick's figure, *Outlines of Physiology*, p. 505.

I pass now to another and very different phase of life, as illustrated in the case of the smaller quadrupeds, known as the Rodents.

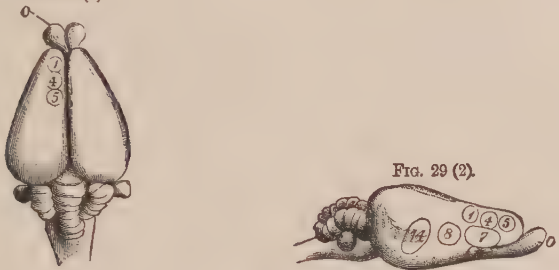

Fig. 29 (1).

Fig. 29 (2).

Fig. 29.—BRAIN OF THE RAT—UPPER VIEW, AND SIDE OF RIGHT HEMISPHERE (*natural*).

(*From* Ferrier's *Functions of the Brain.*)

In the Rat the brain is more elongated, less expanded, and, by the difference of shape, suggests adaptation to a body of different form, and subject to conditions of locomotion quite distinct. The brain is still quite smooth, without trace of even rudimentary convolutions, thus indicating that the grey matter requisite for innervation of the fibres spread over the body can be accommodated within the area of the skull, without doubling or folding of the mass. Whether more may be involved in the convolutions of the grey substance where these appear, such as mental or intellectual action, cannot here be settled; but it is admitted that convolution provides an increased surface, and by so doing may supply an increased degree of nerve force requisite for a more complicated arrangement of nerve fibres. We may, therefore, reasonably infer from the appearance of a smooth brain, that the requirements of animal life in the case under observation are provided for without convolution, that is, without any increase in the amount of cellular matter beyond that easily stored within the cranium.

A marked contrast between the rat's brain and that represented in figure 28, apart from diversity of shape, is the conspicuous place assigned to the olfactory tract. This is shown in the front view, by the two bulbs protruding in front of the hemispheres; and in the side view, by the long broad tract, which passes backwards from the front bulb along the under region of the brain. The optic tract is present, and has its own share of influence, but it is not conspicuous. In the comparison of these two forms of special sense, sight and smell, this case is exactly the reverse of what is found in the pigeon. The bird is guided in all its movements more by sight than by smell; the rat is guided more by smell than by sight.

The numbers seen on the figures represent, under Professor Ferrier's experiments, the same results as were obtained from stimulation of those centres which are similarly numbered on the brain of the monkey, and described in the preceding chapter. This explanation also applies to the subsequent figures, which have numbers on the surface.

Next in order, as presenting a larger example of the rodent type of brain, I take that of the Rabbit.

In this case we have the same characteristics as in the former. Here are the smooth brain, the well-formed cerebellum, and very conspicuous the olfactory bulb in front, with the strong tract proceeding underneath to the rear of the brain. The brain is still of the same elongated form as in the preceding case, but a greater proportionate depth is apparent forward in the organ, which does not slope away to the front so sharply as is the case in the brain of the rat. The optic tract is to be sought concealed in the under region of the brain. But the organ of smell is the determining power in the midst of all the sensibilities and activities of the animal's life. The harmony of this with the well-known habits of the rabbit will be at once recognised. As the animal sits up

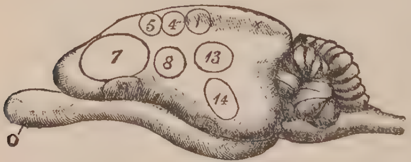

FIG. 30.—BRAIN OF THE RABBIT—SIDE VIEW OF THE LEFT HEMISPHERE (*natural*).

(*From* Ferrier's *Functions of the Brain*.)

on its hind quarters, its sensitive nostrils twitching incessantly, while it sniffs the air, the rabbit is a most striking example of an animal instructed and regulated by its nose. If we venture upon conjecture as to the animal's experience, we may reasonably conclude that it is largely made up of a series of smells, though not exclusively so, as in the imaginary case suggested by Mr. James Mill,[1] in which an animal might be supposed to have no organ but that of smell; for here the other senses are active for the guidance of the animal, though less powerful. And even when we speak of the sense of smell as providing the chief elements of experience, we need to keep in view the usual effects of organic action in all animal life, leading to common experience and common results under guidance of whatever sense happens to be affected.

Continuing up the scale of life, we make the transition to convoluted brains, which still retain the prominent olfactory tract, taking as our first example the Cat's brain.

On looking at fig. 31, it will at once be remarked, apart from the convolutions, which at first are apt to absorb the attention, that a considerable change of shape is appearing as we advance. There is still the elongated form remarked upon when the transition was made from the bird to the rat. But there is here considerably more filling up towards the frontal region, and consequently some approximation towards roundness. With this altered shape of brain must be connected its size and superficial area. The size is very decidedly larger, much more so than can be explained by reference to the comparative bulk of the body in the case of the rabbit and cat. At the same time it must be remarked that the increased size is obtained by development of the organ towards the front, not towards the back. This consideration has the more importance, because afterwards we shall see development proceeding, so as to cover the cerebellum, which is still exposed here. We have undoubtedly, in the example now before us, a more important brain for a more important life. Reference to the results of domestication in the case of the rabbit and the cat confirms and illustrates this superiority in the life of the latter. When to size we add the enlarged area of the grey matter obtained by the variety of convolutions, the increased complexity of the organ is still more obvious, and the inference to superiority of life has additional support. The brain in this case is advanced in form, size, and complexity of structure. I do not here stay to prosecute inquiry as to the higher features of life discovered by observation of the animal's actions. Without resorting to any minute course of investigation, it is well known that the cat has a far more energetic and concentrated use of muscular powers in the catching of its prey, whether that be the mouse, or the smaller of the birds, which escape from danger by instant flight, than the rabbit, which trips out from its cover, bobs along among the grass or turnips, nibbling at its food just where it halts ; and which sits up on its hind quarters at sound of approaching footstep, trips back again to cover, and there lies in shelter until complete quiet reigns around. A further test in the comparison is obtained when we consider the difference of result in the history of the two animals under domestication. This appears in the larger amount of human influence which can be brought to bear upon the cat than upon the rabbit. We are accustomed to speak of the want of "affection" in the cat as contrasted with the dog, and this may be connected with a lower degree of "intelligence;" but every one will admit

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[1] *Analysis of the Human Mind*, vol. i. p. 13.

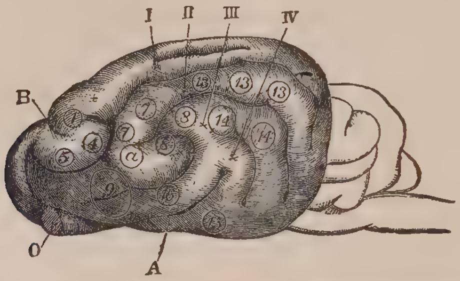

FIG. 31.—BRAIN OF THE CAT—LEFT HEMISPHERE (*natural*).

(*From* Ferrier's *Functions of the Brain.*)

"Left hemisphere of the brain of the cat. A. The fissure of Sylvius. B. The crucial sulcus. O. The olfactory tract, cut. I. The superior external convolution. II. The second external convolution. III. The third external convolution. IV. The fourth external convolution."

that very much more can be made of a young cat than of a young rabbit when brought daily under the influence of a household.

Looking now somewhat more closely at the cat's brain, we observe that the olfactory bulb is still a prominent object. Only a section of it appears in the figure, but the relative thickness of that is enough to show its importance. Yet it is not relatively so important as in the rat and rabbit; and does not appear with projecting points or bulbs so far advanced beyond the frontal region of the brain as in preceding examples. The most marked advance in this brain is the subdivision, which appears both in fissures and convolutions. Springing from the floor of the brain, and running backwards into the substance of it, is the Sylvian fissure (A), exactly similar in position and course to the same fissure in the human brain. By this the organ is divided into front and back regions. There is no such fissure as that of Rolando, but at a point considerably in advance of the position where we should have looked for it, (B), is a fissure named the crucial or frontal sulcus. Next, it will be observed that there are four leading convolutions, marked by the first four Roman numerals; and these do not take the course familiar in the human brain, but run backwards longitudinally, and double round in rear of the Sylvian fissure. By this succession of convolutions there is a much more complicated arrangement of the grey matter, and along with this must be connected the fact that a much larger number of centres is marked on the figure, as responsive to electric stimulation. These, indeed, are so numerous, that, so far as such testimony bears upon the point, we may say there is a very decided approximation to what is found in thebrain of the monkey.

From this example I proceed to that of the Dog, with which some acquaintance has already been obtained.

This brain is obviously on the same model as that of the cat, but is larger, and is more fully developed both in the frontal region and behind. It is still of the elongated shape remarked upon in previous cases, and which appears to be characteristic of all animals which habitually run upon four legs, for there seems to be some adaptation in the form of the organ to the formation of the body which it controls. In harmony with its shape, the convolutions are first seen to run in a longitudinal direction, and then to circle round the Sylvian fissure, after the manner observed in the previous figure. The great leading convolutions are also four in number, but are more fully formed, and more clearly distinguished throughout their course.

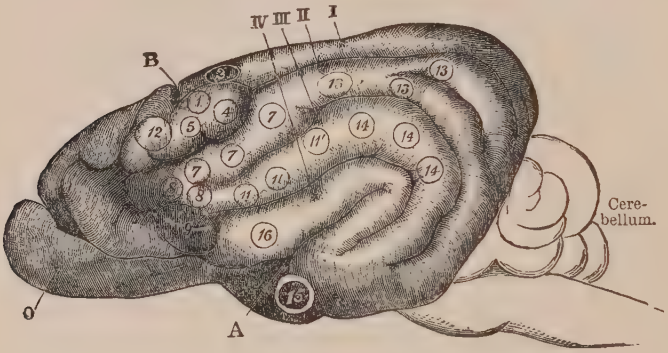

FIG. 32.—BRAIN OF THE DOG—LEFT HEMISPHERE.

(*From* Ferrier's *Functions of the Brain.*)

"Left hemisphere of the brain of dog. A. The fissure of Sylvius. B. The crucial sulcus. O. The olfactory bulb. I, II, III, IV indicate the first, second, third and fourth external convolutions respectively."

The Sylvian fissure (A) occupies a position exactly analogous; but the crucial or frontal sulcus (B) is farther back on the brain, or perhaps its position might be more accurately indicated as nearly the same, but with a considerably larger amount of brain substance in front of it. Quite a prominent feature here is the large olfactory bulb in front, with its strongly developed tract running backwards, and becoming still more enlarged before it disappears underneath, at the region where No. (15) is placed. It is impossible to look upon the provision for the organ of smell without concluding that it has a large influence in the animal's life.

When from external configuration we proceed to the internal structure of this brain (fig. 33), it will appear that there is a close resemblance to what has been found in the human brain.

Within the dog's brain is found the strong connecting band (*corpus callosum*) which unites the two hemispheres, and connects different portions of the grey matter on the two sides. In figure 33 the hemispheres are represented as drawn aside; the connecting band has been cut away, its edge appearing just where the superficial convolutions close (11); and the internal structure of the organ is shown, along with the aspect of the cerebellum when seen from above. A glance at this figure at once reveals great similarity of internal structure with that of the human brain, and large development of the little brain.

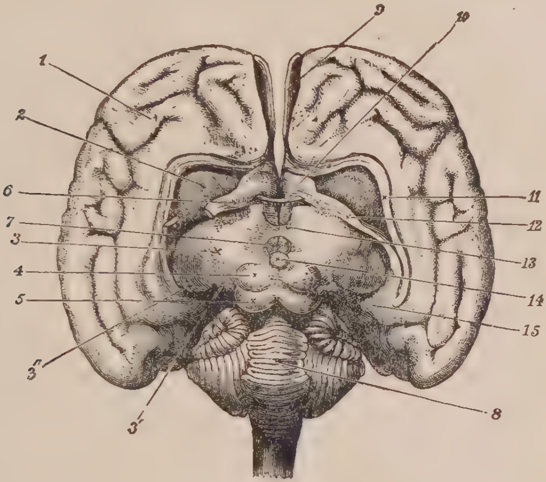

FIG. 33.—INTERNAL STRUCTURE OF THE DOG'S BRAIN.
(*From* Ferrier's *Functions of the Brain.*)

"The Cerebral Hemispheres of the Dog separated after Division of the Corpus Callosum, so as to expose the Ventricles and Basal Ganglia. 1. The internal surface of the left hemisphere. 2. The corpus striatum. 3. The optic thalamus. 4. The anterior tubercles of the corpora quadrigemina. 5. The posterior tubercles. 6. The anterior pillar of the fornix, which is divided on the left, undivided on the right side (12). 7. The third ventricle, exposed by drawing the optic thalami asunder. 8. The upper surface of the cerebellum. 9. The olfactory bulb or rhinencephalon. 10. The anterior commissure. 11. The corpus callosum divided. 12. Fornix, undivided. 13. The soft commissure. 14. The pineal body, situated over and concealing the posterior commissure. 15. The descending cornu of the lateral ventricle."

Looking first at the two main parts, marked on the left side (2 and 3), and taking these with the analogous parts on the right side, we have the two great basal ganglia with their bands of nerve fibre—the one (2) being the *corpus striatum*, composed largely of motor nerves; the other and lower (3) being the *optic thalamus*, composed chiefly of sensory nerves; and just in the middle behind this, the four rounded bodies, which are the optic lobes (*corpora quadrigemina*), of which the two in front are the anterior tubercles and the two in rear are the posterior tubercles, while in advance of these is the pineal body.[1]

Comparison of the external and of the internal structure of the dog's brain with the analogous features of man's brain gives results quite different. The external configuration of the dog's brain with its elongated shape and longitudinal convolutions, differs altogether from that of the human brain. The appearance and arrangement of the basal ganglia are, however, quite homologous with all that is found in the human brain. In this way it becomes obvious, as we ascend the scale of animal life, that though there is considerable diversity in the figure of the brain, and in the manner in which the grey matter is packed within the skull, the internal structure, consequent on the grouping or massing of the nerve lines, is wonderfully like to the structure of the human brain. The resemblance in this latter respect is even so exact that the dog's brain might be employed to illustrate the internal arrangement of man's brain. If we take the terms analogy and homology in the sense given by Professor Owen, the one to represent functional resemblance, the other structural resemblance, we must grant that the internal structure of the dog's brain is homologous with that of man. This result is in obvious harmony with what has been established as to the two sets of nerve lines, sensory and motor, and their relation to the nerve-centre. Every living organism, endowed with sensibility and power of locomotion, must have its lines of sensory and motor nerves, and these must have their supply of nerve energy by direct communication with the grey matter of a nerve centre. The essential feature of the grey matter is not discovered by reference to the manner in which it is laid up in the skull, or the direction given to its folds, but in the cellular nature of the tissue. But sensory nerves must be gathered from all parts, and motor nerves must be distributed to all parts. This being essential to all physical life as known to us, there must be a certain degree of analogy at least between the structure of the lower and higher forms of animal life. And as we rise in the scale to higher orders, there must be close resemblance of internal structure, if the two different sets of nerve lines and the nerves of special sense are to be grouped together in direct contact with the grey matter of the nerve centre.

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[1] For comparison with the human brain, reference may be made to Fig. 11, page 32.

With so many and varied orders of dogs as we have, differing greatly in size, it is impossible to have a figure of a typical brain which can be taken as a guide to the relative size of the organ. But looking simply at the external aspect of the dog's brain, it is clear that the increase structurally, as compared with the brain of the cat, consists in addition to the frontal region, and increased elevation behind, but still without such enlargement in the latter region as to cover the cerebellum.

Thus we have in this case a still more important brain before us than that of the cat. In accordance with this, it will be readily allowed by all that we have superior intelligence in the dog. This superiority appears in so many ways that it becomes difficult to give, within a brief space, a satisfactory summary of its evidence. Volumes can be filled with illustrations of the sagacity of the dog. One has only to refer to the author of *Rab and his Friends* for abundant and very varied testimony to the depth of human interest which may be felt in the dog.[1] So far as I can judge, the dog has a degree of intelligence quite unknown in any other animal, and consequently it is more the companion of man than any other, for it is a real companionship which subsists between the dog and his master. Left to itself, the animal has its low side, and if it know nothing in life but what we may call "self-direction," it may soon be regarded by us as "a vile dog" or "a low cur." But in companionship with man, and under his direction, it is not only active, as it is in almost all circumstances, but affectionate, discriminating, sensitive to a degree unknown in the case of other animals, and even noble in bearing, though this last quality depends greatly on training, and is easily lost.

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[1] *Rab and his Friends*, by John Brown, M.D.

What was said concerning the cat, as to the use of its muscular powers in pursuit and mastery of prey, may be said with increased force as to the dog. The possibility of such energy as a dog displays in pursuit of a hare, or fox, or in tearing up the hiding-place of a rat or a rabbit, implies a high degree of brain development, for it is not mere celerity of movement which is observed, but great muscular effort, which requires not merely controlling power over motor nerves, but abundant supply and free use of a large amount of nerve energy in order that the muscular system may be exerted with so much force. In this consideration alone we have plainly one part of the physiological explanation of increased mass of brain in the dog, in comparison with smaller animals which fall victims under its attack. Strength of muscle and evolution of nerve energy must keep pace with each other.

But it is characteristic of the dog that it can be turned aside from pursuit of prey and led into a different form of life, without abatement of the energy displayed in what may be called the "more natural form of life." Here it is we come upon the evidence of greater intelligence, for it is when the dog comes under training that we find the true measure of the higher power belonging to the animal. It can be trained to a degree of self-restraint quite unknown in the case of the cat, and unapproached, so far as I have gathered, by any other animal which has come under continued influence of man. The dog will indeed steal when he has opportunity of such a kind as implies the entire absence of his master's control, but he will not steal with the promptitude and consummate coolness of the cat. The difference of the two animals in this respect arises largely from these facts, that the dog is much more sensitive than the cat, and is in some respects more liable to continued punishment (for the cat is not trained to obedience by the castigation which is common in the dog's life); and he is more submissive, seldom risking the attack upon his offended castigator, which the cat would very readily attempt.

Beyond this, the intelligence, along with the affection of the animal, is great. I need not here enter into details as to the large appreciation of design shown by the dog trained to point or set when his master is in pursuit of game. The facts are familiar, and the testimony they involve unquestionable. Even more remarkable in many ways is the intelligence of the sheep-dog, which is the daily assistant of man all the year round, and is not kennelled and fed and exercised for months in prospect of a special service required only for a limited period of the year. The "collie" will receive orders, and proceed alone far up the hill-side in execution of them. When thus far removed from his guide, he will interpret such signs as whistling, calling, and gesticulating, and will at once proceed to the execution of the fresh orders signalled to him from a very great distance. Analogous to this is the conduct of the noble breed of "St. Bernard dog,"—those powerful brutes which come rushing out from the Hospice, the whole pack bellowing in a manner sufficiently alarming, and which at once distinguish between the peasant and the traveller, quietly recognising that the latter is privileged with "right of entry," though he has never been seen on the mountain before. When one of these animals goes forth with a monk over the winter's snow, bearing round his neck supplies for the needy, he courses hither and thither in full understanding of his master's purpose, differing widely from that of him who is "bewildered in pursuit of game." Scenting on the breeze enough to direct an animal which is guided more by his nose and olfactory bulb than by any other brain centre, he hurries onward, and, reaching the spot he seeks, speedily makes the snow fly behind him as a minor cur would the sand of a rabbit-warren, and there discloses the human form threatened with an icy grave.

The dog is, as we said, the animal capable of receiving most from human influence, and consequently most sensitive to the indications of human affection or displeasure. No animal dies so readily from deliberate neglect as a dog which has found the daily pleasure of life in attending his master and executing his commands. Besides well-known examples of strong affection, such as that of a dog stretching himself on his master's grave, and refusing to be enticed away, as in the case of the dog celebrated in the annals of Greyfriars' Churchyard in Edinburgh, known as "Greyfriars' Bobbie," we have many examples of extreme suffering under a master's displeasure. I have known two very striking cases of the speedy death of a dog under grief. In one case narrated to me by the owner of the animal, a dog had occupied itself, when the family were absent at church, with pursuing and killing the poultry belonging to the household. After having killed them, it carefully buried them one by one in different parts of the garden, in which the pursuit and slaughter had taken place. Shortly after the return of the family, the absence of the hens was remarked. A search was made, but no trace of them could be found either about the premises or in the neighbourhood. At length the attention of some one was arrested by evidence of the ground in some parts of the garden having been disturbed. The soil was turned up, and the hens' bodies were found. The dog was taken to the garden, and immediately gave signs of guilt. His master took him to his library, and, having shut the door, began a reprimand after this fashion: "What a wicked thing you have done in murdering the hens! You are a minister's dog, and should have been an example to other dogs, instead of doing such a thing as this. Then, this is Sabbath-day, and the deed is all the worse on account of the day on which it has been done." Thus admonished, the dog was put out at the door, and the door shut. Next morning he was found dead. A coroner's inquest was not held, but a veterinary surgeon was consulted, and he gave the verdict, "Died of a broken heart." He said had the animal been well punished, and then received into favour again, all would have been right; but he could not bear to be treated as an outcast.[1]

From the brain of the dog I pass to that of the horse, another animal which has a large share in the interest of man, and also comes very much under human influence.

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[1] I am indebted for this narrative to the owner of the dog, the Rev. Dr. Robertson of Irvine, distinguished equally for his high appreciation of art and his power in preaching the gospel; and known to all his friends as one peculiarly fond of animals.

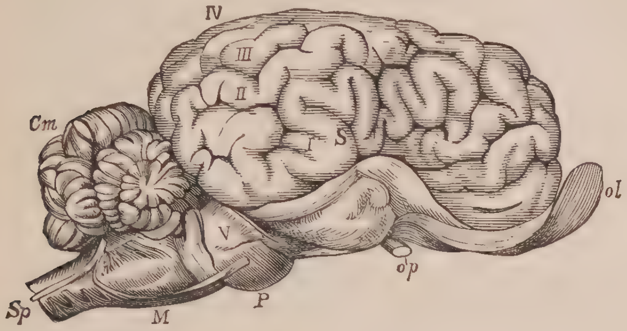

FIG. 34.—BRAIN OF THE HORSE—RIGHT HEMISPHERE. ⅓
(After example in the Atlas of Leuret and Gratiolet.)

Here we have a beautiful example of brain structure. The shape is still of the elongated form seen in the cat and dog; the cerebellum is still uncovered, lying open to view in the rear (*Cm*); but the advance in development of brain is striking and important. The convolutions are peculiarly fine. They are still so far longitudinal in arrangement, as seen in previous examples. This will appear by reference to the convolutions I, II, III, and IV. But there is more appearance of the ascending form of the frontal region, with grouping of subdivisions in the rear; and each convolution is much more distinguished by twisting of its substance than in the case of the cat, or even of the dog. The Sylvian fissure (*S*) is conspicuous as in other examples; but the convolutions are not simply folded round it, in the manner recognised in the two preceding cases. The doubling or twisting, which is a marked feature here, illustrates quite decisively the rule that by this method provision is made for storing a larger amount of the grey matter, and exposing its surface for supply of nourishment carried through the blood-vessels of the pia mater.

Looking along the lower portion of the figure, we have illustration of the special and general arrangements of the connected nerve system. In front there is the prominent olfactory bulb (*ol*), with its distinct nerve tract running back underneath the grey matter, showing a high degree of importance assigned to smell in the government of life. Half-way along appears a section of the optic nerve (*op*), cut at the point where it is seen entering within the central region. Still farther to the rear, and underneath the brain, is seen the bridge (*P*); the medulla (*M*); and the nerve band (*Sp*) proceeding towards the spine.

The horse is an animal so well known, and so constantly rendering service to man, that we are able to form a decided judgment as to its "intelligence." Beyond doubt, it stands high among animals for intelligence, as that is illustrated by capacity for training. It soon adapts itself to the use of harness, and the requirements for being yoked to a carriage; it readily recognises the wishes, and even the peculiar habits of its driver; it shows great tenacity of memory as to locality, going by marked preference in a direction with which it is familiar. We have not in the case of the horse so many special features of attainment as we have distributed amongst the various breeds of dogs. But we are not without examples of special attainment. Such an example is given in the training for cavalry service in our army. The animals, as well as the soldiers, need to be trained to the evolutions belonging to cavalry drill; and they quickly attain familiarity with these, wheeling into position as required. No doubt they are aided, not only by the movement of the reins, but by the muscular strain of the limbs of the rider, as he inclines in the prescribed direction. Nevertheless it is beyond doubt that the horses themselves come to recognise the bugle call, and associate it with the movement required. Our regiments of yeomanry cavalry afford a good illustration. Animals previously accustomed only to ordinary saddle exercise, and others familiar only with the common round of harness work required in agricultural pursuits, learn the military evolutions so well before two weeks of drill are over, that their riders in many cases find their chargers moving in the required direction before they are aware of having indicated it by a movement of the reins. The wonderful feats of selected animals reserved for training with a view to public exhibition afford a striking addition to the evidence we have of the horse's power to appreciate his rider's purpose.

In so far as we observe the self-directed movements of the horse, it is obvious that he is guided chiefly by sight and smell, and of the two senses, chiefly by the latter, in cases where objects appear strange to him. After he has looked at the object for a time, he will approach nearer, and then advancing to it, will bring his nostrils into contact with it, and if there be nothing in the object specially offensive to his sense of smell, he is contented. His interest in the object is at an end, and he no longer gives signs of nervous concern at its appearance. These facts harmonise with the prominence of the olfactory tract and bulb shown in the figure of the horse's brain. In cases of uncertainty of movement, such as are encountered in a very dark night, the horse, by the combined use of both senses, has the advantage over man. Hence it is that, in such circumstances, the rider familiar with his horse will lay the reins loose on his neck and trust to his guidance, rather than attempt to guide him. Many examples are recorded in proof of the wisdom of this course. I give a single instance of the horse's quickness in detecting danger. The incident occurred in the experience of a relative of my own when travelling in South Africa, at the outbreak of one of the Caffre wars, and all the particulars of which I heard from his own lips, as they were afterwards published by him.

"It now became exceedingly difficult and even dangerous either to walk or ride, because the path was very wet, and often nearly precipitous. I now changed my horse again, taking a small pony, too spirited for such a time, but I could better trust his sureness of foot. In order to avoid a part of the road which I knew would be impassable that night, we turned out of the usual line, and in the darkness lost our way. I knew we were approaching somewhere the summit of the mountain, and was beginning to feel a little anxious, when suddenly my horse reared, almost unseating me from the saddle. I spurred him to go forward, but he reared again, and sprang violently back, so that I could scarcely keep my seat. At that moment a vivid flash of lightning illumined the country round; and what did I behold! I was in the act of forcing my horse over a tremendous precipice, the height of which I cannot with certainty tell. It was near the summit of a high mountain, and the descent is nearly precipitous to its base."[1]

In attempting to estimate the comparative intelligence of the dog and horse, it seems impossible to rank the horse as equal to the dog. Here, however, it becomes desirable to have a clear test of the degree of intelligence in animals. Such a test is not readily found in attempting to construct a theory of what may be called "the intellectual acts" in the life of an animal—a kind of minor mental philosophy, applicable to the higher orders of animals. The inner life of the animal is too thoroughly beyond reach of observation to offer us any help. A more hopeful, but still very perplexing, line of inquiry is found in the endeavour to distinguish between what we may still call "instinct,"[2] and what may properly be recognised in advance of that, and accordingly may be designated "intelligence." If we take the observed actions of animals as affording the data, setting on one side those which are reflex actions, including under this designation those which are spontaneous, that is, prompted by the functional activity of certain organs, as in the ordinary search for food; setting on the other side actions implying some appreciation of the adaptation of means to ends, we open up a most interesting line of inquiry. Into this region we shall enter after finishing the investigations as to structure and function. The problems concerned with "Animal Intelligence" will then stand out clearly to view. But while the two structures are before us, showing superiority in the horse, it seems desirable to note the contrasts between the two animals in respect of intelligence. This will give prominence to important facts bearing on the relation of structure to manifestation of intelligence, and will prepare the way for the more detailed inquiry which must follow. Some simple test will suffice meanwhile, and this may be found by glancing at the results of training in the low cases. "The education test" is in a large degree applicable to animals, as well as to the individuals of the human race. With this we may find some clew through the labyrinth, though many of its recesses are left unexplored.

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[1] Calderwood's *Caffres and Caffre Missions*, pp. 190, 191.

[2] Professor Bain well defines Instinct—"Untaught ability to perform actions."—*Senses and Intellect*, p. 261. To this may be added, unreasoning performance of useful actions.

There are certainly no two animals to which the test can be more unreservedly applied than it can be to the dog and the horse—those two most familiar attendants and servants of the human race over a large portion of the globe. Both show a quick and wide appreciation of the purposes of man, and both are constantly under observation. Nowhere along the scale of animal life are we more favourably placed for comparison than here. Comparison therefore should be careful and minute. If additional reason were required for prosecuting comparison, it is to be found in the need for supplementing those observations which have been made by means of electric stimulation of the brain, and for guarding the inferences depending upon this class of observations. For as it cannot fail to be remarked that some animals are more easily obtained than others for purposes of experiment, observations are naturally made on certain classes of animals, while others are excluded from observation. The horse is an animal upon which experiment is not likely to be often attempted, whereas the dog is one of the animals most easily made the subject of experiment. This difference in the history of physiological experiment presents a reason for carefully comparing the brain structure with the evidence of intelligence presented by the two animals. The question is this: If the brain of the horse be the more complex in structure, as illustrated by the elaborate arrangement of its convolutions, is the horse in like proportion more advanced in intelligence? I take the evidence as it is presented by the animals under training.

There is something in the difference of appliances for training the dog and the horse. The whip and the whistle of the dog-trainer, the bit and leathern thong and whip of the horse-trainer, when brought into contrast, tell their own tale. In both cases there is an appeal to fear, as is shown by the presence of the whip,—a necessary appeal in all cases, if inclination is to give way to obedience, and that is the meaning of a regulated life under control of man. Yet the less appeal to fear the better. And, that we may not attach too much importance to the instrument of pain, it is needful to remember that, if the whip be much more in the hand of the controller of the horse than of the governor of the dog, it is used much more as a reminder, by its mere touch, or movement over the back, or by the sound of its crack in the air, to indicate the need for maintaining or quickening the pace, or for exercising watchfulness on some rapid descent, than for the infliction of pain by way of compulsitor or penalty. It would, therefore, be a mistake to argue from the almost constant use of the whip in the management of the horse, that the horse must possess a duller nature, and must show itself less intelligent. In many forms of its use, the whip is merely a sign to the horse, as a word is to the dog, or just as the reins on the neck may be when swayed by the rider, with hardly a tug at the bit. Two things, however, seem obvious when comparing the means used for training and guiding these two animals,—there is more appeal to sight in the case of the dog than in that of the horse, while there is more appeal to the sense of touch with the horse. The dog sees and appreciates far more the visible signs which are made to it than the horse does, and in this we have evidence of a more sharp and discriminating observation. The constant use of bit and rein in the management of the horse shows that he needs more uniform control and guidance. It should be observed, however, that this is in part accounted for by the fact that we exact from the horse a much more constant and uniform exertion of his strength, as we yoke him to a carriage and make him drag it along. In countries where the dog is yoked and made to draw burdens, there is the same resort to the sense of touch, by a dragging movement to one side or the other, though not by appeal to the sensitiveness of the mouth. In both cases there is a resort to force, which indicates that an appeal to intelligence is insufficient. But the much wider appeal to sight and hearing in the case of the dog gives clear evidence in favour of superiority of intelligence.

There is much more of companionship with man in the life of the dog than in the life of the horse. This arises in part from differences of size, form, and strength. On these accounts a considerable deduction must be made from the apparent weight of evidence here as to superiority of intelligence in the case of the dog. Nevertheless, after this deduction has been made, a large margin remains. If we bring into comparison a favourite dog and a favourite horse, and restrict our inferences to the facts connected with direct companionship, it is quite clear that the balance is in favour of the dog. When you go out from the house to a field where both happen to be, both will meet you, both will show signs of pleasure at the opportunity of doing so, and both will receive with marks of attachment the articles of food which you carry to them. But if you walk about the field, or go to work actively within their sight, the dog will give many more marks of appreciation than the horse will do. This is amply illustrated in the harvest-field. When the reapers set to work, the dog will quite recognise that the work is to be continuous, and, retreating to the near shelter of the cut grain, will lie down there, and, though apparently half asleep, he will keep an eye open to the progress of things, and at once detect the signs of intention to stop work. The horse, on the contrary, even with harness on, will eat away where he is left, will lift his head, indeed, as he sees or hears the approach of some one, but will resume eating without concern until the rein is grasped by his driver. No doubt some allowance is to be made for the fact that the dog goes home with his master and is there supplied with the food which the horse finds before him in the field. But, even making allowance for this, attention must be directed to the fact that a closer companionship can be maintained between man and the dog than between man and the horse.

A similar result is reached when we consider the effects of training in the two cases. The dog gazing up into his master's eyes, watching his habits, and set to do many things which he desires to be done, shows a power of appreciation quite unknown in the history of the horse. The range of work is greater in the one case than in the other, and the dog can be far more left to himself in the execution of an order than the horse can. There is nothing in the work of a horse to rival the work of the pointer or of the sheep-dog. The "collie" presents the contrast in the most striking light, for the dog is intrusted with the government of other animals, under direction from his master, and shows himself equal to the task.

The conclusion is confirmed by reference to training of the two animals in what may be described as unnatural action, without using the word unnatural in a condemnatory sense. I refer to the results which follow long training for purposes of exhibition. This is training to mimicry of human action. We have illustrations in training the animals to walk on two feet, or to dance to music. In both cases the results show more of submission to human authority than intelligent use of means appropriate to a given end. And it is well known that the results are attained only by long-continued and painful effort to do what does not come within the scope of the natural activity of the animal. When, however, such attainments are acquired and exhibited, the impression made on the onlookers is quite different. In the case of the horse, the feats are regarded as astonishing, mainly on account of his great size, and the muscular effort needful to accomplish what is done. In the case of the dog, such feats are much more comical, and readily come to be considered ridiculous, simply because the animal has so much more sense, and is able to do so much more nimbly and intelligently what is natural to it, that there is a conviction that the exhibition is not so wonderful as his ordinary engagements.

On the evidence thus presented in outline, it seems clear that the dog has a larger degree of intelligence than the horse. The point of comparison relative to brain structure is thus brought out distinctly. The state of the case is this: the dog, with a brain less elaborate in its convolutions, shows a higher degree of intelligence; the horse, with a more ample and complicated series of foldings in the convolutions of the grey matter, shows less intelligence. What bearing has this contrast on our inquiry? Advance in intelligence and advance in complexity of brain-structure do not keep pace with each other. They are not correlated so as to harmonise. If it be suggested that a great deal more has been done for the training of the dog than for the training of the horse, this is, no doubt, true. This consideration, however, does nothing to lessen the contrast. It makes it more remarkable. More has been done in the one case than in the other, because the one animal is more capable than the other. But specially it is implied that development of intelligence has gone on in the case of the dog, without leaving its impress on the structure of the nerve centre to any such extent as to bear comparison with the brain of the horse.

What account, then, can be given of the greater complexity in the brain of the horse? There is more extensive folding of the convolutions than in any case previously under consideration; this implies a larger amount of nerve cellular tissue within the cranium. What account can be given of this increase? If all the folds of the dog's brain were drawn out, removing all trace of the grooves, and spreading out the grey matter on the level· and if the same thing were done with the convolutions of the horse's brain, the mass would be found much larger in the latter case than in the former. Looked at first by longitudinal measurement, each of the four principal convolutions in the two brains will stretch to greater length in the case of the horse than in that of the dog. Looked at laterally, there is also considerable gain on account of the greater amount of groove to be brought up to the level. Looking at each as an organised whole, when the entire grey substance is packed together as found in the living subject, the result is a much more complex organism in the case of the larger animal. Obviously the first part of the explanation lies in the simple fact of the greater size in the one case than in the other. But in connection with this, the most important element in the explanation is the much more complex muscular system to be controlled. This more highly organised nerve centre is the regulating power over the much larger degree of muscular force which belongs to the body of the horse.

From this example I pass to the brain of the Monkey, recognising always that a clear distinction is to be drawn between the Monkey and the Manlike Ape.

If the monkey's brain (fig. 35) be compared with that of the horse, it will be seen to be in one aspect inferior. It is a brain of simple or unfolded convolutions. In this respect it is analogous to the examples of smooth brain found in the lower orders of quadrupeds, such as the rat and rabbit. On the other hand, it is far removed from the brains of those animals by the divisions of surface which distinguish it. Nevertheless it is wanting in the beautiful windings shown in the brain of the horse. This fact should be noted as an essential point of contrast. This is, indeed, a new type of brain, but a new type starting on the lowest level,—a smooth surface. It is smaller than the brain of the horse, or of the larger dogs. And if we may estimate the grey matter superficially by the levelling up or spreading out of the folds, there is much more to be extended in the case of the horse than of the monkey.

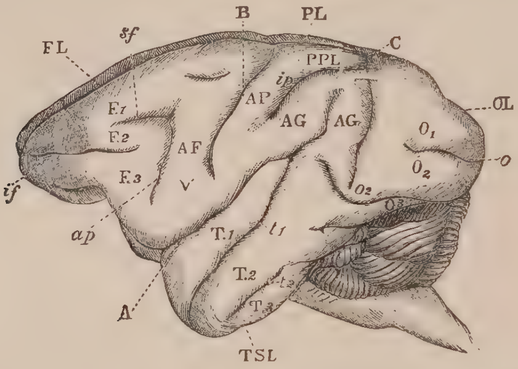

FIG. 35.—BRAIN OF THE MONKEY (MACACQUE)—LEFT HEMISPHERE (*natural size*).

(*From* Ferrier's *Functions.*)

A, the fissure of Sylvius; B, the fissure of Rolando; C, the parieto-occipital fissure; FL, the frontal lobe; PL, the parietal lobe; OL, the occipital lobe; TSL, the temporo-sphenoidal lobe; F_1, the superior frontal convolution; F_2, the middle frontal convolution; F_3, the inferior frontal convolution; *sf*, the supero-frontal sulcus; *if*, the infero-frontal sulcus; *ap*, the antero-parietal sulcus; AF, the ascending frontal convolution; AP, the ascending parietal convolution; PPL, the postero-parietal lobule; AG, the angular gyrus; *ip*, the intra-parietal sulcus; T_1, T_2, T_3, the superior, middle, and inferior temporo-sphenoidal convolutions; t_1, t_2, the superior and inferior temporo-sphenoidal sulci; O_1, O_2, and O_3, the superior, middle, and inferior occipital convolutions; O_1, O_2, the first and second occipital fissures.

At the same time, even with its return to smooth surface, it is so different in form that it may be said to be an entirely new step in the course of brain development. It is as if it had been planned on a new model. The basis of the difference, or essential feature, in the new type, is seen in the fissures dividing the structure into sections or lobes. This is a clear advance. In the brain of the horse the convolutions are beautifully doubled down, giving a series of folds coming in close succession. There is nothing resembling this here. There is, however, not only the Sylvian fissure (A), but the fissure of

Rolando (B), from above, and the parieto-occipital (C) separating the parietal from the occipital lobe. By means of these the brain of the monkey is divided into four lobes, after the manner of the human brain, and which can be similarly designated, the frontal, parietal, occipital, and temporo-sphenoidal. They are marked, outside the line of the figure, by the letters FL, PL, OL, and TSL. Within each division there are separate convolutions, and in the great central portion, where the depth of the organ is greatest, these are laid up in the ascending form (AF, AP, AG), after the model of the human brain. But in the front and back lobes, which are here similar in size and form, they lie longitudinally, with horizontal dividing lines (sulci) between. Another marked feature here is the covering of the cerebellum by extension of the main organ to the rear. There is thus a new form of brain, and it is connected with a new form of body. The adaptation of the body to a semi-erect posture, the capacity for movement upwards, not by bounds, but by grasping one resting-place after another, and the possession of arms and hands, with fingers for clutching branches, according to the requirements of the ascending movement just indicated,—all imply a new and perfectly distinctive muscular system; and this in turn requires a more elaborate nerve system for its management. This correlation of muscle and nerve is the key to the advanced characteristics of the monkey's brain.

For purposes of comparison I give (fig. 36, p. 152) a view of the same hemisphere of the human brain.

Here the two fissures, the Sylvian fissure and the fissure of Rolando, are marked respectively S and R. The third fissure, toward the occipital region, is, however, not clearly marked on the surface of the human brain. The four lobes are marked by the initial letters of their names, the frontal, parietal, occipital, and temporo-sphenoidal.

When the monkey's brain is compared with man's, they are found to have this in common, that the greatest superficial depth is found in the central region. But in man this part is more elaborately constructed. This, we may recall, is the region completely occupied by the centres identified under electric stimulation. These centres were found to be connected with the movements of the limbs, special movement of the hands and feet, and movements of the muscles of the face, operating along with the use of the special senses. Looking now at the contrast between the appearance of the monkey's brain and that of man, and founding our conclusion on the results of electric stimulation, we may say that the monkey's movements must be analogous to those of man, but that human movements concerned with the same parts of the body are capable of being much more complex, involving more intricacy in detail, and much greater amplitude of control. The well-known contrasts in the two forms of life really suggest the inferences thus drawn. Carrying further the comparison of the two brains, they differ most markedly in the front and rear. These two portions are very similar in the brain of the monkey, and they are both much inferior to the same portions in the human brain. In the frontal region the protrusion of an olfactory bulb disappears, and the frontal lobe of the brain itself is developed. In the case of the dog, and still more of the horse, the front portion of the brain appears more folded. The posterior region is more distinctly formed in the monkey's brain than in that of the dog or horse; it is even more sharply marked off than in the human brain. In this portion there is evidence of superiority, which is further marked by the fact that the rear or occipital lobe is carried back, so as to cover the little brain,

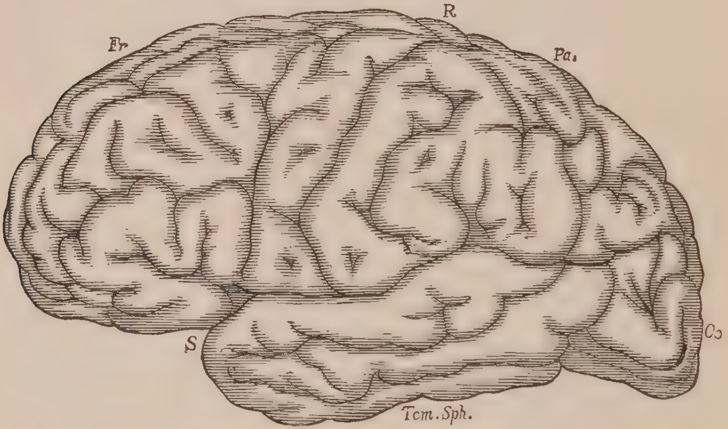

FIG. 36.—LEFT HEMISPHERE OF THE HUMAN BRAIN.

lying here quite underneath the brain proper. In organisation, however, the occipital lobe of the monkey is of the simplest order, and vastly inferior to what is found in the human brain. So far as appears in the outward life of the monkey and of man, there is nothing here to disturb confidence in the results of electric stimulation. The monkey can use an arm as neither cat, dog, nor horse can do. It can use fingers and thumbs as they cannot. In these things the monkey is like to man; the other animals have no such likeness. But, apart from other functions, man can use arms, hands, and eyes as the monkey cannot, and brain structure differs accordingly.

What diversity there may be as to sensibility is a matter more difficult of decision. Observation renders less help in this branch of inquiry. But such forms of sensibility as are connected with muscular action, and use of the special senses, may be said to be common in the two cases. In the monkey, as in man, less prominence is given to the organ of smell than in other orders of life. The phases of sensibility dependent on "voluntary" or "volitional" use of the organs of special sense are matters of personal experience in our own case. They are subjects of observation in the case of the monkey to a very limited extent indeed. The animal is arrested by external objects very much as other animals are. It does, however, manifest a considerable degree of what we may call "curiosity" as to objects attracting its notice. The imitative tendency it shows adds considerably to the impression which such curiosity is apt to make on an observer. If, however, we keep in view the greater reliance the dog places on smell, and notice how persistently the dog tries everything by smell, it becomes difficult to say that the monkey has more "curiosity" than the dog. Allowing for the diversity of organ used, there is fully as much curiosity in the one animal as in the other. There is a combined use of teeth and fingers possible with the monkey which is not possible with the dog, and thus far the former has advantages over the latter in respect of the appliances at command. But, even with these advantages, the intelligence of the one cannot be represented as equal to that of the other. Tested by the possibilities of training, the intelligence of the dog is proved, I think, to be decidedly superior. The monkey is in every way less under command of man for training than the dog, and less fitted for companionship. It is more imitative, and on that account less useful, for feeble imitation is of small account as an aid to man. It is less ready in appreciation of instruction, and less prompt in obedience to orders when recognised. Both of these facts indicate a case less hopeful for training.

In making the transition to the higher orders of the monkey tribe, commonly spoken of as the Manlike (anthropoid) Apes, including the Gorilla, Chimpanzee, and Orang, we have a still closer approximation to the bodily form of man, and a nearer resemblance in the structure of the brain. For illustration of the comparative likeness of the two brains, I have been favoured with the figures prepared for Professor Huxley, and published in his work on *Man's Place in Nature.* The figures have been drawn on a smaller scale than those already given, but this will occasion no difficulty in studying the compara-

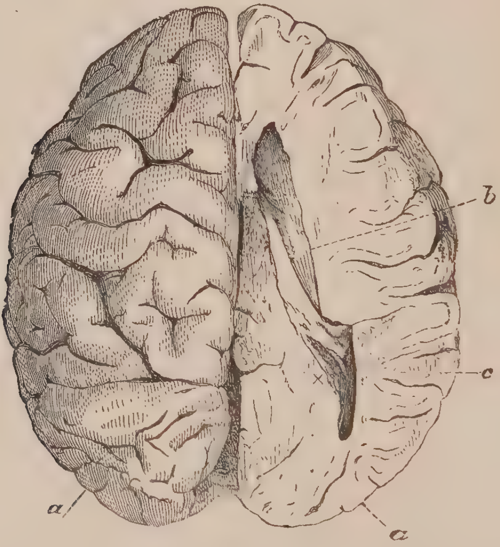

FIG. 37.—UPPER VIEW OF LEFT HEMISPHERE, AND INTERNAL ARRANGEMENT OF RIGHT HEMISPHERE OF THE BRAIN OF THE CHIMPANZEE.
(Enlarged on a scale to equal the drawing of man's brain as shown in the following figure.)
(*From* Professor Huxley's *Man's Place in Nature.*)

tive form, external configuration, and internal arrangement of the organs.

The figure (37) is from a photograph of the brain of a Chimpanzee, which was dissected for Professor Huxley by Mr. Flower, conservator of the museum of the Royal College of Surgeons, London. The parts specially indicated are these,—*a*, the posterior (occipital) lobe; *b*, the lateral ventricle; *c*, the posterior cornu; and ×, the hippocampus minor. The same points are indicated in like manner in the figure of the human brain, given as a companion to this.

These two figures are "drawings of the cerebral hemispheres of a Man and of a Chimpanzee of the same length, in order to show

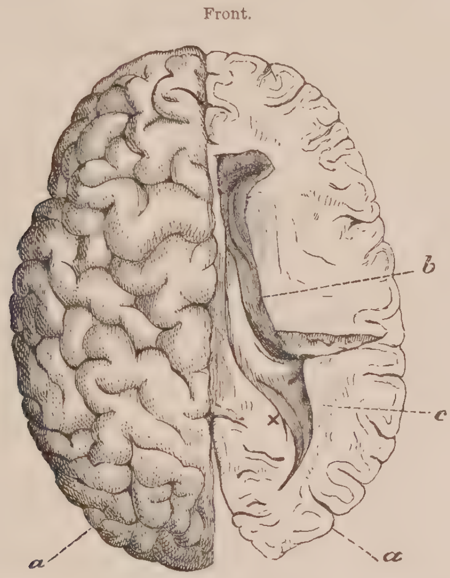

FIG. 38.—UPPER VIEW OF THE LEFT HEMISPHERE, AND INTERNAL ARRANGEMENT OF RIGHT HEMISPHERE OF THE BRAIN OF MAN.
(*From* Professor Huxley's *Man's Place in Nature.*)

the relative proportions of the parts."[1] With the advantages of similarity of scale, there are some disadvantages from comparative enlargement of the brain of the lower order. It must be kept in view that the brain of the Chimpanzee is never more than one-half the size of the human brain, and is generally less than half. Comparing these figures, it becomes plain that the brain of the Chimpanzee is formed exactly on the model of the human brain. The advance from the monkey to the Anthropoid Ape is very marked. The frontal and posterior regions, so defective in the monkey, are considerably more elaborate in the Chimpanzee, and the smooth symmetrical surface of the convolutions has given place to a series of convolutions beautifully folded in numerous windings, closely analogous to the appearance presented in the human brain. If, as is aptly said by Professor Huxley, "the surface of the brain of a monkey exhibits a sort of skeleton map of man's,"[1] this brain of the Chimpanzee shows the map greatly filled in, giving a rough sketch of the general features of the human brain. The resemblance is very close. This fact must be distinctly noted, being certain to have an important significance in any argument founded on comparative brain structure in the various animals. It is disputed whether the Chimpanzee or the Orang is the highest in the class of anthropoid apes. Cuvier placed the Orang highest; but the opposite view has been largely adopted. There is difficulty in deciding, on account of the diversity of age in the specimens obtained. For the purposes of the present inquiry, however, it is of minor consequence whether the Orang or the Chimpanzee be selected as the example with which to institute comparisons. Examination of the skulls in the Edinburgh University Anatomical Museum shows a marked contrast between the three orders. The skull of the Gorilla is more elongated and flattened in form than the other two. The skull of the Chimpanzee is more elevated and round. That of the Orang is decidedly the highest and most rounded of the three.[2] The shape of the skull of the Gorilla favours the conclusion that it is inferior to the Chimpanzee and Orang.

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[1] *Man's Place in Nature*, p. 101.

With the resemblance of brain in anthropoid apes and in man must be connected a certain resemblance in bodily configuration. The two things are intimately related. A body adapted for the erect movement natural to man must be analogous in structure; and where there is some degree of similarity of body, it follows that there will be a similarity of brain structure. These two things are so plainly illustrated by comparison of the anthropoid apes with man, that there can be no risk of overlooking the facts, and there can be no dispute about them. The general truth here is as plain as any fact in Natural History. Analogy of bodily form gives analogy of brain structure. This is the most obvious consideration suggested by simple comparison of the nerve centres in man and in the apes. In physical conformation there is, beside difference of skull, one essential point of contrast between the ape and man. This appears in the formation of the hind feet of the ape. The hind foot is in structure a foot, but in function a hand. It has a thumb, opposable to the toes of the foot, and in this way the ape obtains a firmness of grasp with its foot which is simply impossible for man. This formation is adapted to the animal's life among the trees of the tropical forest, its habits of movement, and modes of gathering food. Those orders most given to climbing, such as the Chimpanzee, have considerably longer fingers than those less addicted to climbing, such as the Gorilla; but all alike have thumbs on their hind feet, and are practically four-handed, hence called quadrumana, notwithstanding a manifest difference between the front extremities and the hind, in accordance with the different use to which the two are put. These hind feet, or "the lower hands, as they may properly be called,"[1] are adapted for a mode of life altogether different from that of the great majority of the lower orders of animals. The figure which is the frontispiece of the work of M. Paul B. Du Chaillu, *Explorations and Adventures in Equatorial Africa*, shows a powerfully formed hand on each of the lower limbs. The distinct feature of this member is completely different from the foot of man, and has so impressed the imagination of the natives of Equatorial Africa as to induce amongst them the belief that with these "lower hands" the ape draws its victims up into the tree on which it is perched.

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[1] *Man's Place in Nature*, p. 100.

[2] This is illustrated by the figures of skeletons in the Museum of the Royal College of Surgeons, London, which are given as the frontispiece to Professor Huxley's *Man's Place in Nature;* by the figures on p. 79 of the same work; and by the plates in Du Chaillu's *Explorations*, p. 373.

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[1] Du Chaillu, *Explorations and Adventures in Equatorial Africa*, p. 62.

The habits of the animal give no warrant for such a fancy, but the existence of this belief shows how these "hands" on the hind limbs have affected the imagination of native observers.

The anthropoid apes move on all-fours when fleeing from danger, but commonly stand in the erect posture when they prepare for attack. They differ somewhat in their ordinary habits of movement. According to Du Chaillu, the Gorilla keeps chiefly on the ground, pulling down the branches in search of berries and nuts, and letting the branches go when supplies are exhausted.[1] He says the common walk of the animal is on all-fours,[2] and when moving in this fashion the tracks show traces only of the heels and knuckles.[3] When the male advances for attack, he rises to the erect posture; his walk is a waddle from side to side;[4] he advances slowly and with a terrific roar; he delivers a fearful blow with his arm, keeping the hand open to give full effect to the claws, and he leaves his victim in anguish just where he falls.[5] The Chimpanzee, a native of the forests of West Africa, lives more uniformly among the trees, and shows great agility, having the aid of long fingers suited for clutching the branches. It also walks on all-fours, resting on the knuckles of the fore limbs and heels of the hind limbs, but it promptly stands erect, and moves readily in that attitude.[6] The Gibbon is another variety, long-armed, and distinguished for agility. The Orang, a native of the forests of Borneo and Sumatra, delights in the profuse growth of the swampy districts. According to Mr. Wallace, "he walks deliberately along the branches, in the semi-erect attitude which the great length of his arms and the shortness of his legs give him. . . . He seizes the smaller twigs, pulls them towards him, grasps them together with those of the tree he is on, and thus, forming a kind of bridge, swings himself onward, and seizing hold of a thick branch with his long arms, is in an instant walking along to the opposite side of the tree."[1] All these accounts agree in referring to the hind foot as distinguished by power in grasping, suited to the requirements of a life spent in the dense forests of a tropical region.

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[1] *A Journey to Ashango Land*, p. 40.

[2] *Explorations and Adventures in Equatorial Africa*, p. 352.

[3] *A Journey to Ashango Land*, p. 40.

[4] *Explorations*, p. 351.

[5] *Ib.* p. 298.

[6] *Ib.* p. 349. Buffon's *Nat. Hist.*

One other feature of these animals calls for remark; that is, the powerful canine teeth. These are the more deserving notice, that the animals are not carnivorous, but live for the most part on berries, nuts, and various leaves. Du Chaillu says of the Gorilla, the fiercest of the three, that the animal is "a strict vegetarian."[2] On this account Du Chaillu felt considerable difficulty as to its teeth, until, he says, I discovered that "several trees, each of which was from four to six inches in diameter, had been broken down by these animals; and I found that they had bit into the heart of these trees and eaten out the pith."[3]

Having now the leading characteristics of these animals before us, as well as the common features of their mode of life, I proceed to compare the brain of the anthropoid ape with the human brain, taking first the frontal lobe. This, in the brain of the Chimpanzee, is considerably developed in form. In comparison, however, with the same lobe in the human brain, it is wanting in depth, and still has something of the pointed shape found in the monkey's brain. This is quite apparent in the examples preserved in the Anatomical Museum of Edinburgh University.[4] In the brain of the Orang the frontal lobe is more rounded.[5] In both these, as well as in the example above (fig. 37), the gyri or folds are quite marked, though not equal to those of the human brain. The posterior or occipital lobe is more full and rounded, and is more closely analogous in complexity of arrangement, though also deficient in development downwards. It is thus, as Marshall states, a brain "somewhat pointed behind, and considerably so in front."[1] Viewing the brain as a whole, and allowing for the smaller size, we may say that no brain could come closer to the human in external structure, without making it difficult to distinguish between the two, or to say with certainty that the examples presented are not varieties of the same order.

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[1] A. R. Wallace "On the Habits of the Orang-Utan," *Annals of Nat. Hist.*, 1856, vol. xviii. p. 27.

[2] *Explorations and Adventures in Equatorial Africa*, p. 348.

[3] *Ib.* p. 290.

[4] For illustration, see plate to illustrate paper of Mr. Marshall, "On the Brain of a Young Chimpanzee," *Natural History Review*, July 1861.

[5] See plates illustrative of Professor Rolleston's article "On the Affinities of the Brain of the Orang-Outang," *Nat. Hist. Rev.*, April 1861.

We are still without investigations into the minute internal structure of the brain of the ape, such as would enable us to compare the several layers of grey matter with those of the human brain. Meynert, in distinguishing between the five-laminated tissue and the eight-laminated, has found that the occipital lobes of the monkey contain more of the eight-laminated tissue than is found in the same lobes of the human brain;[2] but the facts as yet within reach are not sufficient to guide us to a conclusion. In structure and relation of the basal ganglia the brain of the ape is clearly analogous with that of the human brain. The connecting band of the hemispheres (*corpus callosum*) is similar in appearance, though "both shorter and thinner in proportion than in man," as Marshall states.[3] The arrangement of ventricles and basal ganglia is similar, as will be anticipated after the illustration given of the similarity of interior structure in the case of the dog. The size of the nerves is very decidedly larger than in man.

There is thus in the brain of the ape, obviously inferior though it be, an exceedingly near approximation to the brain of man. The ape's brain is less in size by about a half. There is still greater disparity in weight. As above stated, we have an account of two brains (Chimpanzee) weighing respectively 9¾ oz. and 13¼ (Owen's); another of the same order, 15 oz. (Marshall's); a young Orang, 12 oz. (Rolleston's). In contrast, the ordinary weight of brain belonging to a child of about four years is from 38 to 40 oz., while the average brain of an adult is from 46 to 52 oz. No doubt the most of the examples we have of the ape's brain are those of young animals, in consideration of which fact, some addition may require to be made. Yet Du Chaillu says, "the actual increase in brain, in the adult Gorilla (or other anthropoid apes) over the young, is very slight."[1] Bischoff estimates the average at about 15½ oz. In view of these statements we cannot under-estimate if we allow 20 oz. as a maximum. On the other hand, as just remarked, the size of the nerves is larger, and this may point to a much firmer control of the great muscles of the body, with much less minuteness of control over distinct parts. The most prominent and important distinctions in the outward structure of the organ are thus enumerated by Professor Huxley. In the anthropoid apes (1.) "the brain is smaller, as compared with the nerves which proceed from it, than in man; (2.) the cerebrum is smaller relatively to the cerebellum; (3.) the sulci and gyri are generally less complex, and those of the two cerebral hemispheres are more symmetrical; (4.) the hemispheres are more rounded and deeper in man than in the anthropoid apes, and the proportions of the lobes to one another are different. Furthermore, certain minor gyri and fissures, present in the one, are absent or rudimentary in the other."[2] When all these differences are taken into account, we recognise the brain of the ape as a smaller and simpler brain constructed on the model of the human brain.

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[1] *Nat. Hist. Review*, 1861, p. 301.

[2] Dr. Dodds "On Localisation," *Journal of Anatomy and Physiology* vol. xii. p. 654.

[3] *Nat. Hist. Rev.*, 1861, p. 311.

I shall first compare the normal brain of the ape with the human brain, when arrested in its growth. The ape with a brain modelled like man's, and weighing 15 to 20 oz., shows himself active, powerful, and able to assail any adversary: man with a brain better developed, and 10 to 15 oz. heavier, is tottering, feeble, and idiotic, unable to defend himself from even a weak assailant. This contrast seems at least to warrant the conclusion that the larger brain development in man is concerned with a finer and much more detailed nerve system, probably excelling mainly on the sensory side. There are many examples in human history of the brain being well formed, but arrested in process of unfolding. There is in the Anatomical Museum of Edinburgh University (No. 1969), presented by the late Professor Henderson, the brain of an idiot girl, who was not more than eight years of age, which is beautifully formed, but so arrested in growth as to be only a little larger than the ape's brain. The smaller brain of the ape is compatible with maturity of ape life; the larger brain was incompatible with the ordinary functional activity of early human life. There is in the same collection another example, which is the brain of a male imbecile who had a long life, and which shows a development of the several lobes quite beyond the aspect of the ape's brain, yet he was, as is said, "weak in both body and mind." Whatever be the advance in function attendant on advance in comparative development of the brain proper, it is clear that restraint in growth of the human brain does not bring man to a condition analogous to that of the ape. Between the two cases there is such difference, that development of brain in the one case seems concerned mainly with muscular power, which is so superior as to place the animal greatly in advance of man. In the other, development of brain seems much more concerned with increased distribution and co-ordination of sensory apparatus, and so is in closer alliance with intelligence, in which man is immeasurably superior.

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[1] *Explorations*, p. 375.

[2] "On the Zoological Relations of Man with the Lower Animals."—*Nat. Hist. Review*, 1861, p. 79.

In accordance with this view, Gratiolet, while referring to the fact that the arrangement of cerebral folds is the same in the brain of the ape as in that of man, says, "The study of the brain of microcephalic (small-brained) persons has provided me with other elements, by the aid of which the absolute distinction of man is evidently and anatomically proved." He then states that "the temporo-sphenoidal convolutions (lower middle) appear first in the brain of monkeys, and are completed by the frontal lobe; while precisely the inverse order takes place in man, the frontal convolutions appearing first, the temporo-sphenoidal showing themselves last. . . . From this fact, rigorously verified, a necessary consequence follows; no arrest in the progress of growth could possibly render the human brain more similar to that of monkeys than it is at the adult age; far from that, it would differ the more, the less it were developed."[1]

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[1] *Transactions de la Société d'Anthropologie*, Paris—quoted by Du Chaillu, *Explorations*, p. 377.

I pass from this to a comparison of the brain of the ape with the normal human brain, in order to take account both of the differences and the similarities. And first, as to the differences. The normal human brain is considerably more than twice, nearly three times, as heavy as the maximum weight of the ape's brain. The average weight of a human brain in males of the Australian races has been stated at 42·8 oz.; of the African races, 45·6 oz.; of the Oceanic races at 46·5 oz.; and of the European at between 49 and 50 oz., while some examples of the European brain have risen above 60 oz. "The maximum ape's (brain) weight is 14 oz., the minimum human is, speaking roughly, 32 oz. avoirdupois."[1] Relatively to size of body, the full-grown ape is nearly the equal of man in stature. A young gorilla shot by Du Chaillu measured 5 feet 8 inches;[2] another male, 5 feet 6 inches;[3] another, 5 feet 9 inches;[4] a female, which is always considerably smaller, 4 feet 7 inches;[5] another, 4 feet 4 inches.[6] These facts indicate that the brain is a more important organ in human life than in the life of the ape. The superiority in man's case appears still more in the fulness of form and complexity of arrangement in the human brain. The heavier brain is also more elaborately organised. With a stature nearly similar, with muscular development favouring the ape, with configuration of body very analogous, there is nevertheless the clearest evidence from comparison of mere mass and weight of the brain proper, that this organ performs a much more important part in human life than in the life of the ape. And this becomes still more marked when it is added that the cerebellum or little brain is proportionately larger in relation to the brain proper in the ape than in man. Investigations as to the functions of the cerebellum, applying to a great variety of animals, and carried even to the extent of its entire removal, while the animal continued to live, have shown that the cerebellum is not only closely connected with the general government of animal life, but more expressly with co-ordination of movements for equilibrium of the body. Ferrier states the result of detailed experiments in the following terms: "The cerebellum would, therefore, seem to be a complex arrangement of individually differentiated centres, which in associated action regulate the various muscular adjustments necessary to maintain the equilibrium of the body."[1] There is a large amount of evidence in confirmation of this position. If then this conclusion be adopted, it will follow that there is relatively much larger provision in the brain of the ape for maintaining equilibrium as it moves among the trees of the forest than there is in the case of man, who moves more uniformly on an even surface, though his activity takes a much more varied form. The greater proportion of the cerebellum to the cerebrum indicates adaptation to the mode of life of the animal by the difference in the balance of parts included in the encephalon.

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[1] Prof. Turner in *Collected Memoirs of Prof. Rolleston*, p. 49.

[2] *Explorations*, p. 435. [3] *Ib.* p. 276. [4] *Ib.* p. 304. [5] *Ib.* p. 256. [6] *Ib.* p. 261.

The similarity of structure of the brain proper in man and in the ape claims special attention. The analogy is such, that if we lay aside the contrast in these three respects, the order in which the lobes appear, the comparative bulk and weight of the cerebrum, and its size in proportion to the body as a whole, there is a very exact resemblance. This resemblance appears in the form of the hemispheres, in the relations of the lobes, and in the distribution of convolutions. Minuter differences exist, as in the connecting bridges between the occipital and parietal lobes, while the *corpus callosum* is relatively shorter.[2] There is no essential difference in the interior structure of the organ ; nowhere is there a brain approaching that of the anthropoid ape in respect of structural resemblance to the human cerebrum. This is one of the most conspicuous and important facts in the whole line of the present inquiry. It is accordingly to be regarded as a crucial fact for the theory of brain function. For a proper estimate of its significance, it is needful to look at the brain as it stands connected with the bodily structure of the ape, and as it is related to what is known of its intelligence.

The ape is as like to man in physical structure as its brain is like to the brain of man. A harmony of brain and body in each case is an essential feature in the comparison. The differences in bodily conformation have been already mentioned, and need not be repeated. The close resemblance in form and build is very striking, and is amply proved by the likeness of the skeleton in the two cases. Accordingly the muscular system of the ape differs greatly from that of animals more familiar to us, and proportionately it resembles that of man. In harmony with the characteristics of muscular arrangement, and in adaptation to an erect posture, there is a difference in the outward formation of the nerve centre. It is in its adaptation to requirements involved in the bodily form that the brain of the ape possesses its close resemblance to the brain of man. The larger part of the resemblance seems thus explained. Difference of muscular action there is in the two cases, since the ape uses its hands for feet, walking on the knuckles; and uses its feet for hands, gaining largely in security of movement by grasping objects with the foot.[1] But movement in the erect posture, while the fore limbs are used as arms, involves an essential difference in muscular system from what is common in other animals. For this muscular diversity the form of brain found in the ape is the natural equivalent. There is here a first and most important part in the interpretation of homologies. Similarity in brain structure involves similarity in bodily configuration.

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[1] *Functions*, p. 109.

[2] Prof. Turner, *Memoirs of Rolleston*, pp. 14-17.

The ape is far less like to man in "intelligence" than its brain is like to the human brain. Beginning with the physical adaptation of the ape for the acquisition of knowledge, there is far less fitness for acquiring knowledge than there is for active effort to obtain the means of subsistence, or to escape from danger. There is no such sensitiveness in the ape's hand as there is in the hand of man, and no indication in the ape of the power to use the sense of touch as it is employed by man for acquiring knowledge of things around. Thus speaking of the Gorilla, Du Chaillu says, "the arms have prodigious muscular development," but "the palm of the hands is naked, *callous*, and intensely black."[2] The hand which, while it is bare in the palm, is nevertheless "callous," is not the hand of a being capable of "intellectual" development by use of the general sense of touch, which is lowest in the series of the instruments of knowledge possessed by man. Again, the nerves of the ape are relatively much thicker than those of man, suggesting greater command of muscle, rather than fineness of discrimination. Turning next to the results of electric stimulation of the brain, it will be remembered that all the centres of stimulation are gathered on the central portion shown to be concerned in movement of the limbs. From all these things affecting the structure of the brain, it follows that the ape is greatly less fitted in comparison for the use of the physical appliances suited for acquiring knowledge. So far as these considerations carry us, the ape does not rank high intellectually. It is, indeed, acute in hearing, and readily alarmed by the slightest sound; but its acuteness in this respect tends to drive it away from the approaching object, rather than to awaken curiosity as to what is novel. On the other hand, its power of vision is less than that of hearing. There is thus supplied a second instalment towards the work of interpretation. Similarity of brain development does not imply similarity in mental power. Great diversities in intelligence are compatible with manifold homologies in brain structure.

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[1] See Figures 9 and 10 in Huxley's *Man's Place in Nature*, pp. 32, 47.

[2] *Explorations*, p. 357.

To this evidence must be added the statements made concerning the habits of the ape. Of all the species mentioned, the Gorilla is the most fierce and dangerous. The others are less inclined for attack, but even the Gorilla makes his assault only when pressed by the hunter. All three species named above have been under observation to a considerable extent. I shall first consider the habits of the animals in their natural state, and afterwards the results of training.

All three species have their natural resort in the dense forest, and their physical conformation fits them for life among the trees. The Chimpanzee and Orang dwell most commonly up the trees; the Gorilla prefers the level ground, and only the females and young mount the trees for protection. All three feed upon fruit and other vegetable productions; none of them is carnivorous. All possess strong canine teeth, but neither the Gorilla nor the Orang uses these in attack; Dr. Savage says that the Chimpanzee does. They are not liable to attack from other animals, but live a quiet easy life in search of food among the trees of the forest. Mr. Wallace states that, according to the testimony of the natives of Borneo, the Orang or Mias is attacked by no animal save by the crocodile, when the fruit-eater has descended to the banks of the river in search of supplies. At such a time the crocodile has been seen to venture an assault. When this happens, the Orang "gets on the reptile's back, beats it with its hands and feet on the head and neck, and pulls open its jaws till it rips up the throat."[1] This description harmonises with the account given by Du Chaillu of the manner in which the Gorilla delivers his assault with his brawny arm. All three animals are fierce when roused, though the male Gorilla is much the fiercest, being the one most alarmed and enraged by approach of man. The Orangs "seem not much alarmed at man,"[2] on whom they look down with comparative coolness. Dr. Savage tells "that when wounded they have been known to stop the flow of blood by pressing with the hand upon the part, and, when this did not succeed, to apply leaves and grass." All these animals wander from place to place. They never select and retain a favourite place of abode. The male Gorilla commonly sleeps at the foot of a tree, with his back against the trunk, while the female and the young one are in the branches above. The Chimpanzee and Orang sleep up the tree. The Orang makes a nest for itself by breaking off branches and laying them across each other. This appears to be the highest exercise of "intelligence" recorded of it; and the value of this fact is somewhat enhanced by the statement made by Mr. Wallace: "As soon as he feels himself badly wounded, he makes a nest, which, if he completes, is so secure that he will never fall from it."[3] Some have described these resting-places as huts. Dr. Savage says, "Their construction is more that of *nests* than *huts*, as they have been erroneously termed by some naturalists." Such nests afford no shelter, and are occupied only at night.[4] The female is gentle and kind to her young one, which clings so closely to the mother's bosom that hunters often fail to notice the presence of the little one, until the two fall together to the ground.

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[1] *Annals of Nat. Hist.*, second series, vol. xviii. p. 29.

[2] *Ib.* p. 28.

[3] *Ib.* p. 27.

[4] Huxley's *Man's Place*, p. 44.

Andrew Battell states that when travellers in the woods have left their fires burning, the apes "will come and sit about the fire till it goeth out, for they have no understanding to lay the wood together."[1] "The Orang is sluggish. . . . Hunger alone seems to stir him to exertion, and, when it is stilled, he relapses into repose. When the animal sits, it curves its back and bows its head, so as to look straight down to the ground; sometimes it holds on with its hands by a higher branch, sometimes lets them hang down phlegmatically by its side; and in these positions the Orang will remain, for hours together, in the same spot, almost without stirring."[2]

In this narrative I have embraced everything in the natural habits of the ape which appears to throw any light on its mode of life, and specially on its "intelligence." As the result of such a summary of the testimony of skilled witnesses, it is clear that no high degree of intelligence can be attributed to these animals in their natural state. Theirs is a quiet easy life, spent in wandering from tree to tree, eating all the fruit which comes within their reach, and going to sleep when night falls. The nest-building is the highest proof of intellect they give; and in view of what is done in this way by the smaller birds, the fact affords no claim to a high intellectual rank.

When, however, we pass to observations bearing on the conduct of the ape when placed under the influence of man, the case is somewhat improved. Our comparison here is reduced to two of the three apes specially referred to above, for Du Chaillu declares the Gorilla untamable. A young one taken by him, reckoned not more than three years of age, and only two feet six inches in height, proved so powerful that it required four men to master him. When any one approached his cage, he instantly made a rush at the intruder. He would eat nothing but the fruit which was his usual fare, and he showed no disposition to friendliness even with those who fed him.[3] Mr. Ford's testimony is similar.[4] The Chimpanzee and Orang manifest different temper. They too may be fierce when attacked, but they are naturally more gentle, and become readily familiarised with the presence of man when kindness is shown them. Mr. Wallace secured a young Orang, or Mias, which was quite a baby, its age being reckoned at only about a month. It was "quiet and contented." It showed all the characteristics of slow progress towards maturity, with which we are familiar in the human infant. In this respect the Orang was a contrast to a young monkey, which had just got his first teeth, and was placed along with the other. While the Orang was "lying helpless," the young monkey was "examining everything with its fingers, and seizing hold of the smallest objects with the greatest precision." Thus the animal inferior in organisation more quickly reached maturity, in harmony with facts in the life of still lower orders. Bodily development with the Orang is more in harmony with the slow stages of progress in the early period of human life, with this exception, however, that the Orang has a muscular power quite unknown to man. Consequent upon this, there appeared in Mr. Wallace's young specimen a proneness to muscular action in certain forms, much beyond anything usual with a child. It was "contented when it had a bit of rag or stick to grasp." This manifestation of grasping power, and consequent restfulness when exercised, is in harmony with all the habits of the early life of the animal; for, as we have seen, the young ape clings to its mother's body, grasping by the hair or skin. Mr. Wallace's specimen was trained to cling to a ladder, and when it fell from that, "it never seemed hurt by any of its tumbles." It began to "learn to run alone," and "would scream violently when not attended to." The want of sensibility must be noted here, as well as the irritability under neglect. The sensitive part of the body in the ape seems to be the under lip, which is pushed out till it is very prominent. Between the early life of man and the ape there is thus close analogy in respect of slow rate of progress; but there is complete contrast in muscular development, and consequent experience. This contrast points to a divergence of life in the two cases, and to a special and very restricted exercise of brain power in the case of the ape, contrasting decidedly with the ordinary conditions of brain action in human life.

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[1] Huxley's *Man's Place*, p. 4.

[2] *Ib.* p. 34.

[3] *Explorations*, p. 207.

[4] Huxley's *Man's Place*, p. 52.

There is in the ape a certain degree of the imitative tendency, which, however, appears much more fully in the smaller monkeys, and the smallest but most agile long-armed apes, such as the Gibbon. Mr. Wallace's young Orang "would cross his arms like a little Napoleon." Many narratives are given of apes being trained to use knife and fork, and to shake hands, while tricks of an imitative sort, thieving and artful concealment, are all attributed to them. The earliest accounts of them, dating from the close of the sixteenth century, speak of them "imitating human gestures."[1] The strongest testimony on this subject which has come under my notice is that given by Buffon concerning a tame Chimpanzee, named by him an Orang. Professor Huxley, remarking on the fact that Buffon was more fortunate than Linnæus in his opportunity for gaining acquaintance with apes, says of the former, "Not only had he the rare opportunity of examining a young Chimpanzee in the living state, but he became possessed of an adult Asiatic man-like ape, the first and the last adult specimen of any of these animals brought to Europe for many years."[2] Buffon may, therefore, be taken as one of the best authorities as to the ape's powers under training. Speaking of the animal under his own observation, he says: "Its air was melancholy, its deportment grave, its movements measured, its disposition gentle, and very different from that of other monkeys. It had none of the impatience of the Magot (Barbary ape), the ferocity of the baboon, or the extravagance of the monkeys. It may be said that it had been well taught; but the others had also received their education. A sign or a word was sufficient for our Orang-outan, whilst the baboon required the stick, and the others the whip, as they only obeyed under the fear of chastisement. I have seen this animal present its hand to lead out visitors, or walk about with them gravely as if it belonged to the company. I have seen it seat itself at table, unfold its napkin and wipe its lips, use its spoon and fork to carry its food to its mouth, pour its drink into a glass, and touch glasses when invited; fetch a cup and saucer to the table, put in sugar, pour out its tea and leave it to cool before drinking it; and all this without any other instigation than the signs and words of its master, and often of its own accord."[1] This is a striking account of imitative power, and coming from such an observer as Buffon, merits special consideration. The opening statement as to disposition does not give the impression of an animal sharp in observation, or possessed of great power of self-direction. Melancholy, grave, gentle, and patient; these are the qualities specified as prominent. Compared with the characteristics of the monkey, they are nearly the opposite in all respects, so that we might say of the larger animal, that it is less tricky and more submissive than the monkey. The imitative tendency appears strongly, for all the acts described may be classed under the single head of imitated actions. Their value is further diminished by the extent to which they are connected with the animal's feeding, in which the stimulus of the palate renders very efficient aid to the trainer. So much is this the case, that all actions connected with the use of food must be ranked on a decidedly lower level than the actions which accomplish an end of such a nature as to be quite removed from the influence of the animal's taste or appetite. Tried by this rule, the case before us, surprising as it is, stands quite on a low platform as to intelligence. The actions are remarkable when regarded as those of a beast; they are of hardly any account as the actions of an intelligent being. They show intellect enough to notice the use men make of certain articles for conveying food to their mouths, and to imitate them in such actions. But all the actions so imitated are of a nature to be more readily imitated by the ape than by any other animal, on account of the close resemblance of its bodily structure to that of man. The use of the table-napkin is the act which seems to give some gleam of higher intelligence, but it is somewhat explained when it is remembered that the under lip is the special seat of sensibility, and on this account easily acted upon. But the actions themselves make little demand on intelligence. They are such as might be done by a child six years of age without occasioning remark. They are wonderful as the actions of an animal which is higher than man in strength, which has its natural life in the forest, and which obtains its food by plucking fruit from the trees; but the actions are insignificant when regarded as those of an animal whose brain is singularly like that of man. There is on the part of the ape no indication of the aptness for training which has made the horse so valuable as the servant of man. With its great muscular strength the Ape might have rendered powerful aid; but this melancholy sauntering animal, with largely developed muscular system, and with most of the advantages of human configuration, does not show intellect enough to be a fellow-worker with man. In the abode of man it has lost its sphere for the exercise of its muscular energy. With physical organisation suited for work which the horse could not attempt, it accomplishes far less. With a brain formed in much closer analogy with the human brain than that of the dog, and even more obviously than the dog, "walking about with men as if it belonged to the company," it does not show the dog's power to appreciate man's wishes, or to fulfil them by a course of self-directed effort when beyond its master's sight. Greater in muscular development, and decidedly nearer the elevation of humanity in the structure of the brain, the ape is intellectually inferior to the dog and the horse.

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[1] Huxley's *Man's Place*, p. 2.

[2] *Ib.* p. 13.

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[1] *Histoire Naturelle* (1766), vol. xiv. p. 53. For a carefully prepared account of the Apes, see *Museum of Natural History*, by Richardson, Dallas, Cobbold, Baird, and White.

Accordingly, the conclusions of Buffon, after subjecting the animal to careful personal observation, are quite decided. Referring to the imitative acts, he says, "he imitates, but not voluntarily." "He has a body, members, senses, a brain, and a tongue perfectly similar to those of a man, but he performs no action that is characteristic of man." "In relative qualities the ape is further removed from the human race than most other animals." "All the other parts of the body, head and members, both external and internal, so perfectly resemble those of man, that we cannot make the comparison without being astonished that such a similarity in structure and organisation should not produce the same effects."[1]

The results of the comparison between man and the ape presented in the preceding pages, give clear and ample warrant for Professor Huxley's reference to "the great gulf which intervenes between the lowest man and the highest ape in intellectual power."[1]

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[1] *Histoire Naturelle*, vol. xiv. pp. 38, 30, 41, 61. Smellie's Translation of Buffon's *Nat. Hist.*, vol. x. pp. 33, 25, 35, 55.

Professor Huxley, while inclining to a more favourable view of the ape's intellectual condition than Buffon had taken, puts the contrast of action and brain structure so distinctly that I prefer to quote his statements. He says: "So far as I am aware, no one has attempted to dispute the accuracy of the statements which I have just quoted regarding the habits of the two Asiatic man-like apes (the Gibbon and Orang), and, if true, they must be admitted as evidence that such an ape—*1stly.* May readily move along the ground in the erect or semi-erect position, and without direct support from its arms. *2dly.* That it may possess an extremely loud voice, so loud as to be readily heard one or two miles. *3dly.* That it may be capable of great viciousness and violence when irritated; and this is specially true of adult males. *4thly.* That it may build a nest to sleep in."[2] As to comparative brain structure in the case of man and the ape, Professor Huxley says: "So far as cerebral structure goes, it is clear that man differs less from the Chimpanzee or the Orang than these do even from the monkeys, and that the difference between the brains of the Chimpanzee and of man is almost insignificant when compared with that between the Chimpanzee brain and that of a lemur. It must not be overlooked, however, that there is a very striking difference in absolute mass and weight between the lowest human brain and that of the highest ape—a difference which is all the more remarkable when we recollect that a full-grown Gorilla is probably pretty nearly twice as heavy as a Bosjesman, or as many an European woman. It may be doubted whether a healthy human adult brain ever weighed less than thirty-one or thirty-two ounces, or that the heaviest Gorilla brain has exceeded twenty ounces."[3]

A comparison of these two statements, the one concerning the characteristic actions of apes, and the other concerning the close resemblance between their brain and that of man, will show how striking is the problem before us, and how important it is as bearing on the functions of the grey matter of the brain. The first quotation refers to the Gibbon and Orang, but it equally applies to the Chimpanzee and the Gorilla; the last quotation applies to all the three highest orders, leaving out of account the long-armed Gibbon, which moves more by its arms than by its legs.

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[1] *Man's Place*, p. 102.

[2] *Ib.* p. 42.

[3] *Ib.* p. 102.

If now a reference be made to the two figures (pp. 154, 155), the importance of the structural analogy of the two brains will at once appear. Confining attention to the left hemisphere in the two cases, and remembering the enlargement of the representation of the Chimpanzee's brain for the purpose of comparison, it will be observed that the ape's brain is comparatively somewhat broader in proportion. With this difference, both are on the same model, and so like as to appear as if the ape's brain were only a less developed example of the human brain

I have now only to give a summary of the results of this inquiry as to the brain of man and of the ape. The two are similar in the nature and relation of the grey matter and the white, noting only these two points, that we are not in possession of results of minute investigation as to the number and size of cells in the grey matter of the ape's brain, and that the nerve tracts issuing from the ape's brain are stronger than those belonging to man. The two brains differ so far in weight that the maximum brain of the ape is a third less than the minimum weight of the normal human brain. The two brains are closely analogous in structural arrangement, both superficial and internal, embracing within the former the hemispheres, lobes, and convolutions; within the latter, the ventricles and basal ganglia. Thus we have in the ape's brain the closest possible approximation to the human brain—certainly the nearest resemblance known to exist in the animal kingdom; and yet the ape does not show intelligence equal to that observed in the ordinary life of animals whose brains are far from presenting so close analogy with the human brain. So far away is this animal from the intellectual level of man, that it is a "great gulf which intervenes between the lowest man and the highest ape in intellectual power."[1] The brain of the ape, when compared with that of man, supplies the clearest proof presented anywhere by comparative anatomy and physiology, that the structure and form of the brain is no sure index of intellectual power.

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[1] Huxley's *Man's Place*, p. 102.

I close this course of inquiry as to comparative brain structure, by presenting two examples of brain from the more gigantic animals, the first being that of the Elephant.

In examining this example of brain it will be noticed that the Sylvian fissure (S) runs almost directly up to the vertex, nearly dividing the organ into halves. To the left of it there appear three main convolutions, laid up in beautiful and complicated folds. To the right the mass is more extended, and the convolutions still more complicated. The region to the right of the Sylvian fissure is the frontal region, and is more extended, and more varied in form than the portion of the organ which lies behind.

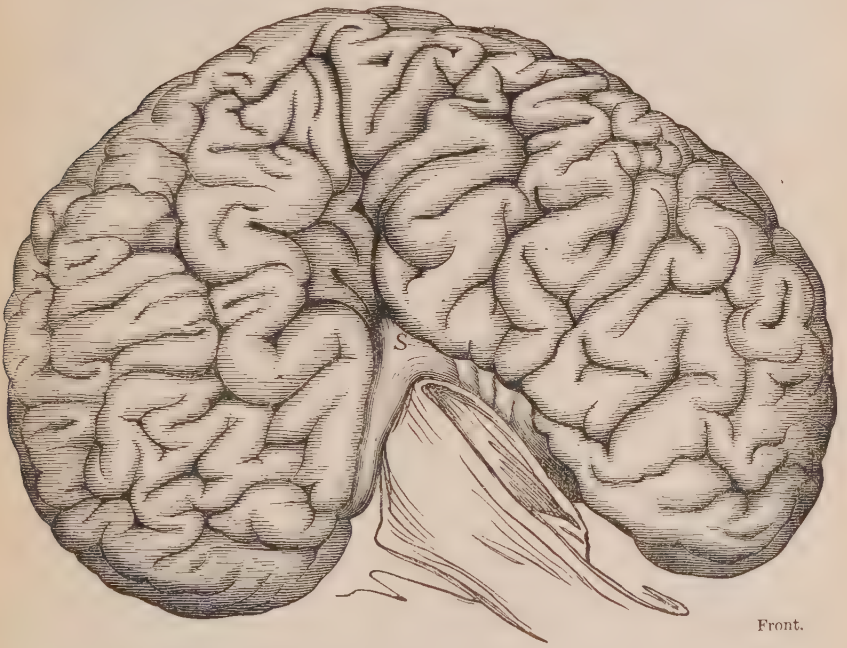

Fig. 39.—BRAIN OF THE ELEPHANT.
(After example in the Atlas of Leuret and Gratiolet.)

When this brain is taken along with others, such as that of the horse and the ape, it is evident that as the brain becomes large, and elaborate in convolution, it stands in close relation with large muscular development. The muscular power of the elephant is well known, as tested by the large weight which it can draw or carry on its back. Mr. G. P. Sanderson, superintendent of the Government Elephant-Catching Establishment in Mysore, speaking of the weight which the animal may carry on his back, says: "Half a ton is a good load for an elephant for continuous marching. In hilly country seven hundredweights is as much as he should carry. I have known a large female carry a pile of thirty bags of rice, weighing 82 lbs. each, or one ton and two hundredweights, from one storeroom to another, 300 yards distant, several times in a morning."[1] Mr. Sanderson's long experience in catching, taming, training, and superintending the work of elephants makes his testimony of special value as to the habits, disposition, and intelligence of the animal.

The great strength of the elephant is certainly the outstanding characteristic which first arrests attention. In illustration of this, very few can be prepared for the statement Mr. Sanderson makes as to the size of the legs. After mentioning that the highest elephant he had seen was 9 feet 10 inches at the shoulder, adding that "there is little doubt that there is not an elephant 10 feet at the shoulder in India," he says, "twice round an elephant's foot is his height, within one or two inches; more frequently it is exactly so."[2] He gives the average circumference of a large male elephant's foot as about 4 feet 8 inches, the diameter being about 18 inches. As to the early period at which a calf elephant is able to go with the herd of wild elephants on the march, the following information is given:—"When a calf is born the herd remains with the mother two days; the calf is then capable of marching. Even at this tender age calves are no encumbrance to the herd's movements; the youngest climb hills, and cross rivers assisted by their dams. In swimming, very young calves are supported by their mother's trunks, and held in front of them."[3] "Calves are always quick movers. I have used them as small as thirteen hands at the shoulder, with a soft pad and stirrups, bestriding them as a pony. They are wonderful little creatures for getting up or down any difficult place, they give no trouble, and will keep up with a man running at any pace before them."[1]

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[1] *Thirteen Years among the Wild Beasts of India*, p. 87.

[2] *Ib.* p. 56.

[3] *Ib.* p. 51.

Though so early able to endure the fatigue of marching, elephants are long in attaining maturity. "The elephant is full grown, but not fully mature, at about twenty-five years of age. At this period it may be compared to a human being at eighteen; and it is not in full vigour and strength till about thirty-five."[2]

A conspicuous feature in the conformation of the elephant is the trunk, which, as an additional limb, virtually performs the functions of an arm, while the animal retains its solid foothold on all four legs. The trunk is at the same time an organ by which, as well as by the throat, sound is emitted. "A peculiar sound is made use of by elephants to express dislike or apprehension, and at the same time to intimidate. . . . It is produced by rapping the end of the trunk smartly on the ground, a current of air, hitherto retained, being sharply emitted through the trunk, as from a valve, at the moment of impact."[3] The trunk is a sensitive portion of the body, its extremity, with slight prominence, being distinguished by a delicate power of touch. "Whilst fording water on cold nights, tame elephants curl up their trunks and tails to keep them out of it."[4] Mr. Sanderson speaks of the "attitude elephants often assume when in uncertainty or perplexity, putting the trunk into the mouth, and holding the tip gently between the lips."[5] When the animal is attacked by the natives, spears are "thrown at his trunk and head."[6] Mr. Sanderson denies that the trunk is used as a weapon of offence, but affirms, in opposition to the statements of Sir Emerson Tennent, that the tusks are regularly so employed—"Far from tusks being useless appendages to elephants, and of little service for offence, they are amongst the most formidable of any weapons with which nature has furnished her creatures, and none are used with more address." Mr. Sanderson also contradicts the current impression that the trunk is used for lifting heavy weights, and so brushes away by a single sweep all the fine stories in which we have taken delight as to the wonderful feats of strength by use of the trunk. He says that "small trees are overturned by pushing with the curled trunk, or feet if necessary."[1] But as to the more ordinary uses of the trunk, he makes the following important statement:—"Much misapprehension prevails regarding the uses and power of the elephant's trunk. This organ is chiefly used by the animal to procure its food, and to convey it, and water, to its mouth; also to warn it of danger by the senses of smell and touch. It is a delicate and sensitive organ, and never used for rough work. In any dangerous situation, the elephant at once secures it by curling it up. The idea that he can use it for any purpose, from picking up a needle to dragging a piece of ordnance from a bog, is, like many others, founded entirely on imagination. An elephant might manage the former feat, though I doubt it; the latter he would not attempt. Elephants engaged in such work as dragging timber invariably take the rope between their teeth; they never attempt to pull a heavy weight with the trunk. In carrying a light log they hold it in the mouth as a dog does a stick, receiving some little assistance in balancing it from the trunk. Tuskers generally use their tusks for this and similar purposes, and are more valuable than females for work. An elephant is powerful enough to extricate a cannon from a difficult situation, but he does it by pushing with his head or feet, or in harness—never by lifting or drawing with his trunk. . . . Elephants do not push with their foreheads, or the region *above* the eyes, but with the base of the trunk, or snout, about 1 foot below the eyes."[2] When the wild elephant makes an attack, "the head is held high, with the trunk curled between the tusks, to be uncoiled in the moment of attack."[3] "An elephant rarely uses its trunk for striking other elephants or man. Newly caught ones seldom even seize any one coming within their reach with their trunk; they curl them up and rush at the intruder."[4] The ordinary use of the trunk is gathering food, in the shape of grass, leaves, and tender twigs.

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[1] *Thirteen Years among the Wild Beasts of India*, p. 88.
[2] *Ib.* p. 60.
[3] *Ib.* p. 49.
[4] *Ib.* p. 51.
[5] *Ib.* p. 54.
[6] *Ib.* p. 60.

As to the cranium and brain, Mr. Sanderson gives the following information:—"Internally the cranium consists of light cellular bone of very open construction. The walls between the cells are as thin as note-paper. The cells differ in size; the largest has a capacity of about two wine-glasses. There are no powerful bones, except one knob in front; a walking stick may almost be driven through an elephant's skull from the sides. The only vital portion of the head is the brain; this lies low and far back. In a very large male elephant, say 9½ feet at shoulder, its extreme length horizontally is 12 inches, and vertically 6 inches. Its shape is somewhat oval."[1] From the last statement I infer that the brain *in situ* may have the mass somewhat more extended than is represented in the figure of Leuret and Gratiolet given above.

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[1] *Thirteen Years among the Wild Beasts of India*, p. 66.
[2] *Ib.* p. 82. [3] *Ib.* p. 189. [4] *Ib.* p. 82.

From these important statements bearing upon the physical structure, I pass to the testimony Mr. Sanderson gives concerning the disposition and intelligence of the animal.

As to the general disposition and temper of elephants, our author says: "The elephant stands unrivalled in gentleness."[2] "Their good qualities cannot be exaggerated, and their vices are few, and only occur in exceptional animals."[3] "The elephant's chief good qualities are obedience, gentleness, and patience. In none of these is he excelled by any domestic animal, and under circumstances of the greatest discomfort, such as exposure to the sun, painful surgical operations, etc., he seldom evinces any irritation. He never refuses to do what is required, if he understands the nature of the demand, unless it be something of which he is afraid. The elephant is excessively timid, both in its wild and domestic state, and its fears are easily excited by anything strange."[4] Mr. Sanderson speaks of the best elephants having "the eye full, bright, and kindly;" but in the worst specimens the "eye is piggish and restless."[5] "Elephants can always be guided, except when frightened, by the slightest tap with a small stick on either side of the head, the pressure of the knee, or even by a word; but if alarmed, they have to be controlled or urged forward by the driving-goad."[6]

As to intelligence, Mr. Sanderson ranks the elephant decidedly lower than has commonly been done. He says, "he is certainly neither imbecile nor incapable." At the same time this experienced witness considers it an animal not possessed of a high degree of intelligence. "Though possessed of a proboscis which is capable of guarding it against such dangers, it readily falls into pits dug for catching it, and only covered with a few sticks and leaves."[1] If a young elephant fall into a pit, "the mother will remain until the hunters come, without doing anything to assist it." "These facts are certainly against the conclusion that the elephant is an extraordinarily shrewd animal, much less one possessed of the power of abstract thought to the extent with which it is commonly credited. I do not think I traduce the elephant when I say, it is in many things a stupid animal; and I can assert with confidence that all the stories I have heard of it, excepting those relating to feats of strength or docility performed under its keeper's direction, are beyond its intellectual power, and are mere pleasant fictions."[2] He adds: "I have seen the cream of trained elephants at work in the catching-establishments of Mysore and Bengal; I have managed them myself under all circumstances; and I can say that I have never seen one show any aptitude in dealing, undirected, with an unforeseen emergency."[3] "The opinion is generally held by those who have had the best opportunities of observing the elephant, that the popular estimate of its intelligence is a greatly exaggerated one, and that instead of being the exceptionally wise animal it is believed to be, its sagacity is of a very mediocre description. Of the truth of this opinion no one who has lived among elephants can entertain any doubt. It is a significant fact that the natives of India never speak of the elephant as a peculiarly intelligent animal; and it does not figure in their ancient literature for its wisdom, as do the fox, the crow, and the monkey. . . . One of the strongest features in the domesticated elephant's character is its obedience. It may also be readily taught, as it has a large share of the ordinary cultivable intelligence common in a greater or less degree to all animals. But its reasoning faculties are undoubtedly far below those of the dog, and possibly of other animals; and in matters beyond the range of its daily experience it evinces no special discernment. Whilst quick at comprehending anything sought to be taught to it, the elephant is decidedly wanting in originality."[1]

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[1] *Thirteen Years among the Wild Beasts of India*, p. 190.
[2] *Ib.* p. 62.
[3] *Ib.* p. 81.
[4] *Ib.* p. 82.
[5] *Ib.* p. 84.
[6] *Ib.* p. 89.

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[1] *Thirteen Years among the Wild Beasts of India*, p. 80.

[2] *Ib.* p. 80.

[3] *Ib.* p. 81.

The example of brain structure with which I close this chapter is that of the Whale

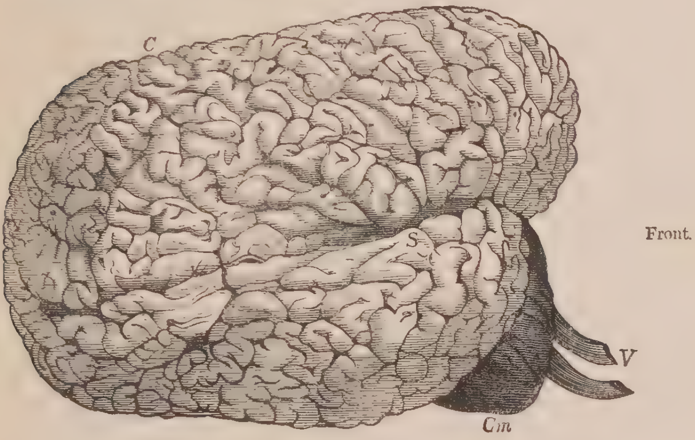

FIG. 40.—BRAIN OF THE WHALE—RIGHT HEMISPHERE.—
THE CAAING WHALE (*Globicephalus Melas*) ½.
(From Nature, after a Photograph from Specimen in possession of Professor Turner.)

This is an example of very great interest in its relation to all the problems involved in the comparative anatomy and physiology of brain structure. This interest arises not so much from the size of the organ as from the wonderfully elaborated and beautifully arranged convolutions. The difficulty of the study of this brain is greatly increased by the comparatively small knowledge we can have of the habits of the animal. The only observations we possess on the minute structure of the whale's brain are those recently published by Dr. Major on the brain of the Beluga or white whale.[2] That author has shown that one of the chief differences between the brain of the whale and that of man is a relatively smaller number of large nerve-cells in the third layer of the grey matter of the whale's brain. This inferiority must be considered along with the distribution of grey matter in much more numerous and minute convolutions—two facts which involve a very important contribution to the materials at command for study of the functions of the brain.

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[1] *Thirteen Years among the Wild Beasts of India*, p. 78.

[2] *Journal of Anat. and Physiol.*, January 1879.

The interest awakened by the configuration of the brain is heightened by the consideration that the whale ranks among the Mammalia. It is, indeed, popularly classified with fishes, principally because of its form, and also because of its life in the waters. Its real position, however, is among the Mammalia, as it belongs to the class of animals giving suck to their young. Further, it is an animal which manifests strong affection for its young. These considerations add greatly to the importance of this example of cerebral structure.

The first point calling for remark is the change of form appearing in this case. The large mass of the cerebrum is placed within the skull in a manner quite different from that seen in the case of quadrupeds such as the dog, horse, or elephant, and also different from that found in cases where the bodily structure is such as to admit of an erect, or even semi-erect posture on two feet. It is laid along the back region of the head in such a manner that the Sylvian Fissure (*S*), takes its rise from the anterior region of the cerebrum, and just above the cerebellum (*Cm*), instead of taking its rise from the base of the cerebrum, and in front of the cerebellum, as in the other cases represented. The position is altogether strange. The formation of the skull differs proportionately with that of the brain, the bones of the face being elongated, and the cranium flattened and elongated.

The brain of the whale, though large in the scale of brains, is decidedly small relatively to the size and weight of the animal's body. Some estimate in these respects may be formed from the account given by Dr. Scoresby of the observations as to a young whale of comparatively small dimensions, so that the animal was lifted completely on deck. The fact that the largest whales are cut up while floating in the water makes it impossible in their case to take accurate measurements. The young whale referred to by Dr. Scoresby was "19 feet in length, and 14 feet 5 inches in circumference." I give entire Dr. Scoresby's passage as to the brain:

"The brain lies in a small cavity in the upper and back part of the skull. The cavity included within the *pia mater*, exclusive of the *foramen magnum*, measured only 8 inches by 5. The upper part of the brain lies very near the surface of the skull. The convolutions of the cortical substance lie in beautiful fringed folds, attached to the medullary portion, which is white, as in the human brain. The general appearance of the brain is not unlike that of other Mammalia, but its smallness is remarkable. The quantity of brain in a human subject of 140 or 160 pounds weight is, according to Haller, 4 pounds; in this whale of 11,200 pounds (5 tons), or seventy times the weight of a man, the brain was only 3 pounds 12 ounces. According to Cuvier, the brain in man varies from one thirty-first to one twenty-second part of his weight, whereas in this animal the proportion of brain was only a three-thousandth part."[1]

The most striking feature of this brain is the wonderfully intricate arrangement of convolutions. Nothing in the scale of brain structure which has come before us in the preceding course of observation, approaches it in minuteness of folding. This intricacy of superficial arrangement must be set over against the small size of the organ. If we are correct in regarding it as a law in brain structure, that folding of the convolution is the method employed for increasing the area of grey matter within the cavity of the skull, that law has most striking illustration here. The nervous system connected with the organ does not appear to be complicated, being mainly connected with two organs of special sense, sight and hearing, and stretching down the spinal cord to embrace the muscular system, which is huge in proportion, rather than intricate in arrangements. In the young specimen described by Dr. Scoresby, the length of the body was 19 feet, while the length of the cavity containing the brain was only 8 inches. In a paper read before the Wernerian Society, the same author says: "The whale, when full grown, is from 50 to 65 feet in length, and from 30 to 40 in circumference immediately before the fins."[1] Taking the maximum length here mentioned, and estimating the cranial cavity at the same proportion as in the young whale (in all probability it will be somewhat larger), we have 27 inches, or a little over 2 feet, as the length of the cranial cavity, while "the jaw-bones, the most striking portions of the head, are from 20 to 25 feet in length;[2] and the entire body from 60 to 65 feet. The brain is, therefore, small in length relatively to the extent of the body. But what is wanting in length is made up in complexity. Division into lobes similar to those found in other orders could not be attempted in this case; and yet, in addition to the great Sylvian fissure, there are obviously certain deeper sulci breaking off from the Sylvian fissure, which may be found to have some value for purposes of subdivision, if greater familiarity with the organ were attained. Meanwhile, however, it may be regarded as certain that the great multitude of grooves, and singular minuteness of folds, point to a proportionate increase in area of the grey matter, and suitable provision for blood supply. And, if these things be admitted, we have a further indication of the conclusion, supported by the brain of the elephant, that cerebral structure has at least one measure of the intricacy of its convolutions in the mass and power of the muscular system which it controls. Some estimate of the muscular power of the whale may be formed from what Dr. Scoresby has said in the following passage as to the small cub or "sucker" already referred to:—"The muscles about the neck appropriated to the movements of the jaws, formed a bed, if extended, of nearly 5 feet broad and 1 foot thick. The central part of the diaphragm was 2 inches in thickness. The two principal arteries in the neck (the carotid) were so large as to admit a man's hand and arm."[3]

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[1] *Journal of a Voyage to the Northern Whale-Fishery in* 1822, p. 150. Dr. Scoresby remarks that the proportion between brain and body in man is less on an average than that given by Cuvier. This is confirmed by what has been already stated, p. 22.

The other parts of the body which are of most interest as bearing on the muscular strength of the animal are the fins and tail. Dr. Scoresby, speaking in this case of the full-sized whale, says, "The fins are from 4 to 5 feet broad, and 8 or 10 feet long, and seem only to be used in bearing off their young, in turning, and giving a direction to the velocity produced by the tail." The anterior extremities are of a formation which warrant their being spoken of as rudimentary arms, the bones being somewhat analogous to those of the fore limb in other mammalia. They are sometimes named "paddles," and not inappropriately it was suggested by the Rev. John Fleming, when describing a Narwhal cast ashore in Zetland, that they might be named "swimming-paws."[1]

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[1] *Memoirs of the Wernerian Society*, vol. i. p. 578.

[2] *Ib.* p. 579.

[3] *Journal of a Voyage*, p. 150.

In explanation of the propelling power, Dr. Scoresby thus describes the tail of the full-grown animal—"The tail is horizontal, from 20 to 30 feet in breadth, indented in the middle, and the two lobes pointed and turned outwards. In it lies the whole strength of the animal. By means of the tail the whale advances itself in the water with greater or less rapidity; if the motion is slow, the tail cuts the water obliquely, like forcing a boat forward by the operation of *sculling;* but if the motion is very rapid it is effected by an undulating motion of the rump."[2]

As to the special senses, Dr. Scoresby says, "The eyes are very small, not larger than those of the ox, yet the whale appears to be quick of sight."[3] The organ of vision is protected by a peculiarly strong sclerotic coat. Dr. Scoresby adds, "In the whale the sense of hearing seems to be rather obtuse." In the *Journal of a Voyage* (p. 154), the following interesting additional information is given:—"The whale has no external ear; and the opening of the passage to this organ is so small, as not to be easily discovered. In the sucking whale it is only one-sixth of an inch in diameter. An elegant contrivance appears in the meatus auditorius externus, for protecting the ear against pressure from without. It consists of a little plug, like the end of the finger, inserted in a corresponding cavity in the midst of the canal, by a slight motion of which the opening can either be effectually shut, for the exclusion of the sea-water, or unclosed for the admission of sound."

The female whale shows strong affection for its young. Dr. Scoresby says: "Its maternal affection deserves notice. The young one is frequently struck for the sake of the mother, which will soon come up close by it, encourage it to swim off, assist it, by taking it under its fin, and seldom deserts it while life remains. It is then very dangerous to approach, as she loses all regard for her own safety in anxiety for the preservation of her cub, dashing about most violently, and not dreading to rise even amidst the boats."[1]

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[1] *Memoirs of the Wernerian Society*, vol. i. p. 134.

[2] *Ib.* p. 580.

[3] *Ib.*

In the course of these investigations as to the results of comparative anatomy and physiology, as bearing on brain structure, repeated reference has been made to the degree of intelligence manifested by different animals. I reserve for a subsequent chapter the problems connected with a theory of animal intelligence.

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[1] *Memoirs of Wernerian Society*, vol. i. p. 585. For structure and proportions of the skull of the whale, see Professor Turner's *Account of the Great Finner Whale* (Balaenoptera Sibbaldii) *stranded at Longniddry.*—Transactions of the Royal Society of Edinburgh, vol. xxvi. p. 197; and, by the same author, paper *On the occurrence of* Ziphius cavirostris *in the Shetland Seas, and a comparison of the Skull with that of Sowerby's Whale.*—Trans. Roy. Soc. Ed., vol. xxvi. p. 759.

CHAPTER VI.

RESULTS OF ANATOMICAL AND PHYSIOLOGICAL INVESTIGATIONS.

A STAGE has now been reached in course of this inquiry which makes it desirable that we should take a general survey of the position. The ground which has been gone over is extensive, and there is need for retrospect, with the view of obtaining a harmonious conception of the results. The range of inquiry still before us is large, and what remains to be done depends to a great extent for its satisfactory accomplishment on keeping clearly before us the more prominent features of the investigations already made. A statement of results, therefore, seems an essential requisite at this stage, with the view of preparing the way for deliberate treatment of the relations of mind and brain.

The first and most general result is, that there is similarity of structure and function of the nerve system in all animal life. In every case the nerve system consists of two sets of fibres, sensory and motor, uniting in a centre, which may be a single cell, or a mass of cells. The homology is clear and undisputed.

The structure of the nerve fibres is the same, though their functions so far differ that some are sensory, others motor. Contrast of function does not arise from diversity in the fibre itself, but from difference in the terminal arrangements. The sole distinction is found in the fact that those fibres which are motor in function are distributed to the muscular system, while the sensory are distributed to the skin, and organs of special sense, and are provided with terminal organs sensitive to a variety of external impressions.

The nerve centre itself is in all cases composed of the mass of nerve fibres brought to unity at the central terminus, and a mass of grey cellular matter conjoined with the collected fibres. These two substances are united in every example of a nerve centre. The function of the grey matter is to evolve the nerve energy, needful for the activity of the nerve fibres.

While the nerve centre is analogous in structure in all cases, there is great diversity of arrangement as we ascend the scale of animal life. Only in the lowest forms of organism is the nerve centre a single ganglionic mass. As the muscular system increases in complexity, so does the nerve system, and as the nerve system becomes more complex, so does the nerve centre. This complexity of the nerve centre wears two aspects; *first*, the multiplication of ganglia which unitedly constitute the central system; and *second*, more involved or elaborated structure of the cerebrum or brain proper, as the chief organ in the central system. In the vertebrates, the central system has its lower extreme in the spinal cord, its higher extreme in the cerebrum. Every distinct nervous mass lying between these has its own distinct share of nerve-cell tissue. The medulla, pons, and cerebellum have their own appropriate supply, as well as the spinal cord and the cerebrum. Within the cerebrum itself, the basal ganglia and the lobes of special sense illustrate a further application of the same rule, for they also are distinct formations, with their own share of grey matter. There is therefore considerable variety of arrangement connected with the distribution of the nerve cells. But this does not seem to imply diversity of function. Everywhere the grey matter is cellular, everywhere it is situated in direct relation with nerve fibres, and everywhere it evolves nerve energy, which is discharged along those nerve fibres in immediate connection with it. When, however, the cellular substance of the brain is placed under the microscope, there is found to be some difference in the minute structure of parts. Thus, the neuroglia is more abundant in the outer layers, and the nerve cells less numerous; whereas, in the layers more deeply situated, the cells are not only more numerous, but larger in size. Still, these diversities do not imply any deviation from the common functions of nerve cells. It is not implied that the grey matter gathered in separate masses fulfils four distinct functions, according as it is found in the medulla, pons, cerebellum, or cerebrum. So far as anatomical and physiological results guide us, there is no evidence on which to maintain an essential difference either of structure or of function. Everywhere the cell evolves nerve energy. Of these cells there are two chief classes, the one sensory, the other motor. The sensory cell is receptive of influence from without. The motor cell gives rise to an impulse which is carried downwards to the muscular system. Beyond these two outstanding distinctions, the only problem which may occasion debate is this: Can warrant be found for assigning any special function to the larger cells, more particularly the giant pyramidal cell? This question will have attention directed upon it ere long.

Thus arises the problem as to the kinds of work done by nerve cells and nerve fibres. Much uncertainty still hangs over the molecular changes which go on in the cellular mass constituting the common feature of a nerve centre. What is known naturally raises the question,—how much can be done by nerve cells? We must seek at least to approximate towards a determination of the limits of functional activity in this case, knowing that cells perform very different functions in different parts of the body. Some precise knowledge we must have of the work daily executed by the brain, for only thus can we advance towards a conclusion combining the testimony of anatomical and physiological science on the one hand, and of mental philosophy on the other, as to the intelligence and will-power which together perform so conspicuous a part in human life.

The accompanying diagrammatic representation will aid our attempt to summarise results.

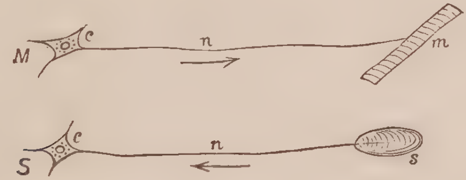

FIG. 41.—DIAGRAMMATIC REPRESENTATION OF THE RELATIONS OF MOTOR AND SENSORY APPARATUS.

M, Motor apparatus; *c*, Motor cell; *n*, Nerve; *m*, Muscle. *S*, Sensory apparatus; *c*, Sensory cell; *n*, Nerve; *s*, Sensory corpuscle, as in touch. The arrow indicates, in each case, the direction in which the impulse is conveyed.

The distinction between the motor and sensory arrangement is found in the contrast of peripheral structure. The cell and the nerve are common to both. The difference is, that there is at the outer extremity of the fibre in one case a muscle, in the other a touch-corpuscle, or other sensitive terminal organ. The composition of the nerve is, as we have said, the same in both, and no distinction has been recognised between the cells other than that which is found in their relation to a particular nerve fibre. While, however, the contrast between the two arrangements is found at the outer extremity of the nerve fibre, the shock or impulse which brings the fibre into action is delivered at the opposite ends of the line. In the case of the motor nerve, the impulse which originates activity is discharged at the end where the cell is, and the consequent motion is downwards. In the case of the sensory nerve, the stimulus is received where the touch-corpuscle, or other peripheral terminal organ, is placed, and the movement communicated to the nerve fibre takes an upward course. I begin with the SENSORY APPARATUS. Excitability belongs to the corpuscle or other terminal organ, fitting it for impulse or stimulus from without. We know that ordinary tactile impression will communicate an impulse to the touch-corpuscle,—that light will find a sensitive terminal organ in the retina, though nowhere else in the body,—and that sound-waves will find their sensitive part in the slender nerve fibres set up in the labyrinth or inner chamber of the ear. There is diversity of terminal arrangement in the three cases, providing for different forms of tactile impression, but in all the three an impulse is communicated to the terminal organ, and a movement takes place up the nerve fibre. This movement of the fibre must result in some movement, impression, or change in the cell connected with the sensory nerve, and this must in some way represent the impression at the periphery. We must, however, begin with the fibre, and its movement, under stimulus delivered at the periphery. And here there are two essential features. *First*, the sensory nerve is maintained in the sensitive condition which constitutes preparedness for nerve action, only by direct vital relation with the cell. This is a feature common to the sensory nerve and the motor. *Second,* the movement in the sensory nerve is the result of impulse communicated from without the nerve system, not from within. This forms a contrast to what is true of the motor nerve. As to the vitalising or innervating influence coming constantly from the cell to the fibre, it seems unnecessary to speak particularly, since it is a common characteristic of the whole nerve system.

There remains, therefore, the problem raised by impulse or stimulus communicated to the sensory nerve. This problem includes these elements—excitability at the peripheral extremity, movement along the nerve fibre, molecular action of the nerve cell resulting from movement along the nerve fibre, and sensation as a matter of experience. Each one of these four in reality presents a distinct problem. Only by harmonious solution of the four can we have a scientific explanation of the activity of a sensory nerve. It may be well therefore briefly to state what present knowledge seems to warrant.

1. Active sensibility at the peripheral extremity depends upon three things,—vital relation of the peripheral organ with the nerve cell; adaptation of structure in the peripheral organ to tactile influence; direct contact with some external surface. The general tactile sense may be takèn as illustrating all sensory activity. The two first-named elements are the common requisites for tactile impressions. The last-named is that which is the immediate occasion of an exercise of sensibility. With those facts must also be taken the additional facts connected with our experience of pain, for these must have a conspicuous place in connection with a theory of the action of sensory nerves. While ordinary tactile impression is agreeable and compatible with uniform exercise of the nerve as a means of knowledge, application of force, as from a blow, or an impression which penetrates through the skin to the terminal organ, as the prick of a needle or a cut, occasions pain, the severity or acuteness of which is incompatible with the ordinary use of the sensory corpuscle, as an instrument of knowledge. If instead of touch we have violent concussion or actual injury, there is temporary interference with the normal use of the sensory nerve as an instrument of knowledge. Taking together the ordinary tactile impression, which is agreeable,

and the very familiar experience from the shock or injury which occasions pain, the sensibility of the peripheral organ seems to carry a large part of the explanation of the movement along the nerve fibre. In the one case there is a quiet, rhythmic movement; in the other a disturbed, convulsive movement. That the movement along the nerve fibre is an example of molecular movement, is matter of general agreement among neurologists. But in constructing a theory of sensation we must take into account such facts as these—that the slightest tactile impression is sufficient to secure activity of the sensory nerve; that there is necessity for at least a slight impression, in order to maintain the normal function of the fibre as an instrument of knowledge; and that a shock of considerable force, or actual injury to the terminal bulb, or coil, or other organ, occasions convulsive movement, inconsistent with the normal action of a sensory nerve. Excitability in the corpuscle, and conductivity in the fibre, are essential and distinct features accounting for the movement, which results in that form of experience known as sensation. With increase of excitation coming from without, there is increase in sensation according to a logarithmic ratio. Beyond a given point pain supervenes, from which it follows that the normal action of the sensory corpuscle is restricted to the lower degrees in the scale of impression.

2. Action of the corpuscle, or other terminal organ, occasions movement of the correlated sensory fibre. The movement of the terminal organ acts upon the conductivity of the fibre, and on account of the presence of nerve energy or nerve fluid, supplied from the nerve cell, the impression conveyed to the fibre does not merely influence the lower end of it, and gradually pass off, but the movement is propagated with equal facility up the whole length of fibre. This propagation of nerve influence, indicated by movement in the nerve fibre, takes effect quite irrespective of the length of the fibre brought into action. The length is according to the distance of the terminal organ from the nerve centre. In the case of the general tactile sense, the length varies according to the surface of the body, some fibres stretching to the fingers, others to the toes. With all the special senses the nerve fibres are short, for the terminal

organs are all situated in the region of the head, where communication is very direct. According to variations in length there will be variations in the time required for propagation of the movement, in accordance with calculations such as those of Helmholtz. But the conducting of impressions along the nerve is accomplished with facility whether the line be long or short.

3. Action of the sensory nerve cell must be the result of the impulse being conveyed along the nerve line. It is not affirmed that the movement of the related cell has been matter of direct observation, as in the case of the two preceding facts. But it is matter of the clearest inference, supported not only by the whole analogy of the nerve system, but by a series of clearly verified facts which imply it. As the nerve has its central terminus in the cell, the movement from the periphery along the line must cause molecular movement in the cell. The impulse communicated to the touch corpuscle implies a shock to the nerve cell.

4. A definite form of experience, known as a Sensation, is the result of the action of the sensory apparatus. If the normal rhythmic action of the nerve take place, the sensation is agreeable, and conveys to us some knowledge of the object brought into tactile relation with the finger or other part of the body. If a disturbed, convulsive movement take place, the sensation is painful and disturbing, preventing us from making ordinary use of the sensory nerve as an instrument of knowledge. Whether the sensory cell has sensibility such as belongs to the touch corpuscle has not been established. That it is liable to molecular change must be admitted; that this implies movement in the cell, and also the possibility of communicating movement to a motor cell, is certain; but we cannot affirm that excitation or disturbance in the sensory cell implies sensibility, any more than we could affirm that sensibility or feeling is characteristic of the related cell, which brings the motor apparatus into action. We are, however, safe in declaring that "the cells undergo certain molecular modifications, which coincide with certain subjective changes constituting the consciousness of the impression."[1]

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[1] Ferrier's *Functions*, p. 257.

Passing now to the MOTOR APPARATUS, we find an arrangement exactly analogous to that of the sensory, save that a muscle occupies the place of the peripheral sense-organ. This, however, implies an entire difference of function: for the impulse which brings a motor nerve into action is delivered at the cell, that is, within the nerve centre, and not at the extremity. Here the nerve cell is doing what the sensory cell does not ordinarily accomplish, and which, nevertheless, a sensory cell may induce by acting upon the motor cell. For, muscular activity may be occasioned either by the action of a sensory cell upon the motor cell, in the manner described, or by a volition, as when a person voluntarily raises his arm. What is involved in this volition will be considered in a subsequent chapter. The order of events to be explained is the following:—Movement within the motor cell; discharge of nerve energy down the motor nerve; action upon the muscle, liberating the energy which is stored there, and which is greater than the nerve energy acting upon it; and consequent movement.

1. By impulse or shock given to the motor cell it is brought into activity, so as to discharge nerve energy. For origin of this cellular action there is need of some influence external to the cell. As we have seen, there are two perfectly distinct lines of explanation. *First,* Movement is accounted for by communication of impulse from a sensory cell. This cell, being itself thrown into action by impulse received at the peripheral organ, sends forward the impulse to the motor cell, which thereupon discharges nerve energy down the motor nerve. The real origin of this activity is external impulse, and this illustrates a type of spontaneous action common to all living organisms. Such organism is thus far shown to be a self-adjusting mechanism, operated upon from without. In this respect the action of the nerve system is the same, in whatever organism it exists. Any difference which here appears between ourselves and the animals, arises from evidence that the sensori-motor system is more fully under our control than is the case with the animals. Stimulus coming from physical appetite, known as "visceral impression," illustrates the same law of sensori-motor action, as excitation beginning at the periphery. *Second,* Movement in the motor cell is further accounted for

by impulse from some inner sphere, apart from the action of a sensory cell. There is an originating impulse aside from the sensory system. Movement of the fingers in writing implies muscular action correlated with thought and volition, in a manner quite unknown in mere sensori-motor activity. The pen gives outward expression to thought, in obedience to impulse communicated from the Will to the motor cell.

2. By action of the motor cell movement is propagated down the motor nerve. This nerve is thus a communicating fibre between the motor cell and the muscle. The structure of the motor nerve being the same as that of the sensory nerve, the action is the same, though the impulse is carried in the opposite direction.

3. By impulse from the motor nerve, muscular energy is liberated, and a new power is brought into action. In accordance with the position (p. 79) established by Haller, that contractility of muscle does not depend upon the motor nerve, though acted upon by its instrumentality, a new and more powerful form of energy is brought into application. The muscle can do work which the nerve cannot perform, yet the nerve impulse liberates the muscular energy, sets it in action, and is sufficient to keep it in action, until a sense of exhaustion gives warning of the need for rest and nourishment. But, on the other hand, nerve energy is insufficient to account for the resultant action, which is explained by a form of energy belonging to the muscle itself, and depending on the property of contractility belonging to muscular tissue. Professor Tait has put the distinction admirably in these words:—"It seems, from the observations of physiologists as to the formation of cellular matter, and the production in living organisms of compounds which have not yet been made by ordinary chemical processes, that the vital force, if there be such [let us say, 'nerve force'], is not a force which does work, but merely *directs*, as it were, the other natural forces *how to apply* their energies."[1] As, then, the outstanding characteristic of the sensory apparatus is sensibility to external influence, that of the motor apparatus is power to do work in an external sphere.

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[1] Article *Force; Energy.* Chambers's *Encyclopædia.*

4. Joint action of the several muscles concerned provides for movement of a limb. The work done by the arms and the legs is thus dependent proximately on muscular activity, that again upon the impulse coming from the nerve fibre, and that upon communication of impulse from the nerve cell.

I pass now from the nerve cells to the ganglionic masses which make up the nerve centre.

Whatever diversity exists between the sub-divisions of the great central arrangement arises from the number and distribution of nerve fibres connected with particular parts. Thus the several portions of cellular matter diffused within the spinal marrow are, in a manner, separate centres providing for reflex action through means of the sensori-motor fibres united in them. So it is with the lobes of special sense, and with the basal ganglia. The cerebellum has also its own gathering of fibres and cells, and its functions are to be found by reference to these. So it is with the cerebrum. If, therefore, the question be raised,—Why should the Cerebrum be regarded as the principal body in the encephalon?—the simplest and most direct answer is,—Because it is largest and is central for the whole, including the spinal marrow, the lobes of special sense, the basal ganglia, and the cerebellum. Subordinate portions of the central system are only minor centres for the segregation or combination of sets of fibres, which nevertheless have their true central terminus in the brain proper. The combined anatomical and physiological results are therefore accurately represented if we say that the Cerebrum is the grand centre which provides first for sensibility by receiving the impressions made on the sensitive surface, and second for motor activity by supplying the impulse which excites muscular energy. The two sets of apparatus are compacted and harmonised so as to constitute a unity, harmonising dual lines of sensibility, as in the case of the special senses, and double sets of motor nerves spread over both sides of the body.

The one clear outstanding result is this,—IN ALL KNOWN LIVING ORGANISM, BRAIN IS THE CHIEF ORGAN OF SENSORI-MOTOR ACTIVITY. Accordingly, the leading demands upon the organ are these:—To supply nerve energy adequate to keep the whole sensori-motor apparatus in condition for functional activity; to provide for transmission of impulse, whether occasioned by external impact, or by visceral or other internal excitation; and to secure co-ordination of all sensory and muscular activity according to the requirements of animal life. These are the functions common to the brain, as the grand centre of a nerve system. The marvellously complex forms of sensibility and activity natural to the higher orders of animals are all dependent on the nerve system, and all the multifarious combinations requisite within the unity of animal life are provided for by action within the great central body, the Brain.

CHAPTER VII.

ANIMAL INTELLIGENCE.

If now we inquire how the functional activity of Brain stands related to Intelligence, we raise a new and entirely distinct problem. In doing so we pass from the common characteristics of the nerve system, to the specialities of a higher order of life, illustrated by the superior vertebrates. The mere introduction of the question concerning Intelligence seems to draw within a more restricted circle of classification a limited number of superior races, including, without doubt, as conspicuous examples, the dog, horse, elephant, monkey, and ape. The animals named are not by any means similar in their characteristics. They even differ very widely; but no one would propose to exclude any of them from observation when dealing with Animal Intelligence. On the other hand, there is not any recognised authority on neurology who would at all favour the representation that Intelligence is uniformly attendant on a nerve system. That a nerve centre is the organ of sensori-motor activity, is uniformly true; but no one affirms that wherever a nerve centre exists there is intelligence. For no one will propose to assign intelligence to the jelly-fish, star-fish, snail, and centipede, though no one denies to them sensibility and motor activity. The problem is, therefore, a new one, requiring a distinct course of investigation, after having classified the common characteristics discovered by neurology.

We wish to ascertain what is meant by Intelligence as attributed to animals, and how this intelligence stands related to Brain function. We seek to have it determined what is the exact meaning of the statement that Brain is the organ of

Mind, and how it stands related to the other statement, that Brain is the organ of Sensori-motor Activity. For satisfactory treatment of this new and very difficult question, it becomes needful to take a survey of the whole phenomena of nerve action, that they all may be considered anew as they seem related, or not related to the standpoint we are now occupying. For we wish to discover whether all neurile phenomena are in relation with manifestations of intelligence; and, if not, how it comes to pass that only some phenomena of nerve action are associated with intelligence. Further, to guard against risk of confusion, and to prepare the way for systematic treatment of the subject, it seems desirable to confine attention to the testimony of ascertained facts, and to avoid even provisional definitions of terms. On this account, we shun definitions of instinct, consciousness, reason, knowledge, mind, "mental habits and actions" (Darwin), "psychical states" (Herbert Spencer), and the more questionable term "Ideation" (Lewes). We prefer altogether to avoid definitions, to accept the more general term intelligence, with the popular award assigning intelligence to a given number of animals, and to study unreservedly the whole facts, in the hope of attaining definite conclusions.

A summary of ascertained positions as to comparative brain structure and functions will best prepare the way for warrantable induction as to Intelligence.

I.—STRUCTURE.

1. In all cases, the nerve system consists of two sets of nerves, sensory and motor, meeting in a central organ. This arrangement constitutes a vital unity. In the vertebrates, the central organ is constructed in two hemispheres related to the two sides of the body.

2. With advance in organism, there appear distinct lobes for organs of special senses. These lobes are distinct nerve centres closely connected with the brain, and the special senses for which they provide are supplementary to the general sensory system. There is no analogous supplement in the structure of the motor system.

3. In the higher animals, the chief masses of sensory and motor nerves belonging to the general nerve system are gathered together in distinct ganglia at the base of the brain. These ganglia (thalami and striata) are in a sense subordinate centres, while they constitute integral parts of the brain. The thalamus, lying in the rear, is composed mainly of sensory nerves; the striatum, in the front, mainly of motor nerves. From both, fibres radiate to all the four superficial lobes of the brain, frontal, parietal, temporo-sphenoidal, and occipital.

4. Of the subordinate bodies, the cerebellum, or little brain, is the largest. It is closely related with the cerebrum, and, as the centre of co-ordination for muscular movements involving both sides of the body, it may be viewed as an addition to the motor system, somewhat compensating for the addition to the sensory apparatus of the lobes of special sense.

5. Within the brain proper, besides the sensory and motor nerves gathered from all parts of the body, there is a large number of fibres providing for intercommunication within each hemisphere, and from one hemisphere to the other.

6. The grey matter, which is the distinctive feature of every nerve centre, is composed mainly of nerve cells. These vary considerably in size and form, some possessing few, others numerous lines of communication, and some are so distinguished for their size as to have been named giant pyramidal cells.

7. Cells of large size are spread over different portions of the central arrangements of the nerve system. In man, large cells are found in the spinal cord, in the sympathetic system, and within the grey matter of the hemisphere, chiefly in the fourth layer, while many of them are gathered about the ascending frontal convolution.

8. Comparative anatomy of brain discovers considerable diversity in the proportion of subordinate centres to the brain proper. In some inferior orders, as fishes, there is an actual preponderance of the optic lobe over the cerebrum; in birds, the optic lobe, though less than the brain, is larger in its proportion to the brain than holds true higher up the scale; still higher, as in dogs, with comparative diminution of the optic lobe, there is great increase in the proportionate bulk of the olfactory tract and lobe; again, in the monkey, in the ape,

and in man, there is a comparative reduction of the olfactory apparatus, with fuller development of brain.

9. As to differences of form and appearance in the brain itself, the lower orders of animals have a smooth brain; with the cat and dog, a folded or convoluted brain appears; the monkey's brain is smooth as compared with the ape's; the ape's brain is analogous in appearance to the human brain; while, with animals of great strength, such as the elephant and whale, the grey matter of the brain is folded in elaborate convolutions.

These statements contain a summary of all that is most important in our present knowledge of the structure of nerve and brain. With guidance of these, it becomes obvious that, in tracing the arrangement of the sensori-motor system, the whole nerve system is included from the extremities to the brain proper. In view of this fact, we are prepared for recognising the delicacy and difficulty of the problem concerning Intelligence, here coming fully into view as we pass to the functions of the brain.

II.—FUNCTIONS.

1. In all cases, the nerve centre, whether a mere ganglion or a complex assemblage of bodies crowned by the cerebrum, is the governing organ of a nerve system.

2. The common and invariable functions of a nerve system, with its governing centre, are those performed by means of its two sets of fibres, sensibility and motor activity. From the first appearance of a nerve system, these two functions are performed by it; and these two continue invariably the outstanding characteristics.

3. Sensory and motor nerves are not found to differ in structure, and the functions of both are fulfilled by a form of motion propagated along the fibres; on the one side, this motion, starting at the periphery, and carried along the nerve fibre, is communicated to a nerve cell in the nerve centre; on the other side, movement is started at the centre, continued along the nerve fibre, and communicated to the muscles. Propagation of motion is thus a uniform characteristic of functional activity in the nerve fibres. In the one case, motion results in

impression or sensation; in the other, motion results in muscular action, or it may be in locomotion.

4. Motion propagated by sensory apparatus may pass through central organs to the motor apparatus. Such reflex action may be produced through the agency of a subordinate centre, without intervention of the brain, or it may involve brain action. Such action and reaction illustrate the co-ordination of the two sides of the nerve system, providing for motor activity in harmony with sensibility.

5. Sensori-motor activity is characteristic of all nerve systems, even the lowest, and is purely mechanical, involving no intelligence. Such reflex action is clearly distinguishable in human experience from intelligent action, and this distinction must be taken as one of the most important bearing on the problem of intelligence. Personal experience is conclusive as to the thoroughgoing distinction between sensori-motor activity and intelligent action. Professor Huxley states the contrast thus as it bears on "volition," which, on the lowest interpretation, must include intelligence as a factor, "this reflection of motion from a sensory into a motor nerve may take place without volition, or even contrary to it."[1] Here, then, is a fundamental distinction, universally recognised, and vital to the whole discussion. Sensori-motor activity is the antithesis of intelligent activity. As far as the sensory apparatus can of itself produce movement over the motor apparatus, so far can motor activity be explained without interposition of Intelligence.

From the possibilities of united or reflex action of the two sets of nerves, we are able to interpret the possibilities of each side of the nerve system, when acting separately. The sensory system is discriminative, in the sense of receiving distinct forms of excitation, according to diversity of external impact: the motor apparatus is purposive, in the sense of accomplishing a definite intelligible end; and these functions are fulfilled without intervention of intelligence, or of any other agency beyond the two sets of nerves and related cells, which may be united by intra-cerebral fibres. Correlated action is illustrated in the Ascidian mollusk, already described, p. 123, which

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[1] *Science and Culture*, p. 210.

Carpenter takes as "the simplest form of a definite nervous system."[1] "These animals are for the most part fixed to one spot;" "the external envelopes have two orifices, a mouth to admit water into the pharyngeal sac, and a vent for the expulsion of the water." "When any substance, the entrance of which would be injurious, is drawn in by the current, its presence excites a general contraction of the muscular envelope; and this causes a jet of water to issue from one or both orifices, which carries the offending body to a distance."[2] This may stand as the typical illustration of nerve discrimination on the one side, and purposive action on the other, without intervention of intelligence, and by mere mechanical contrivance. As organism becomes more complicated, the arrangements of sensori-motor apparatus become more intricate, but this complexity involves nothing new in function.

Here comes into view the first important restriction on popular thought as to animal intelligence. In human life discrimination and purposive action very generally involve intelligence; and we naturally attribute intelligence to animals in accordance with our own power of interpretation of their experience and conduct. The facts of reflex or sensori-motor activity, however, place a definite scientific restriction upon such a method of interpretation. This is readily recognised in certain cases. We do not fall into the mistake of attributing intelligence to an Ascidian mollusk fastened upon a stone under water; or to a jelly-fish floating in the water, and constantly contracting and expanding. But when organism becomes more complex, and the modes of functional activity are more concealed, we more readily attribute intelligence where we find purposive action. Yet is it established beyond possibility of dispute, the Ascidian and the jelly-fish themselves affording ample testimony, that purposive action is no sure proof of intelligent direction. Inference to the contrary involves the fallacy of attributing without warrant the conditions of human life to lower orders of organism. The extent of restriction thus to be assigned is at this stage quite uncertain; the rule itself is quite clear,—sensori-motor activity is the antithesis of intelligent action. The task is to ascertain the full extent of sensori-motor activity in animal life. Our question is, how far is sensori-motor activity of the nerve system the explanation of observed activity in animal life? How far, for instance, is the activity of the monkey, and even of man, strictly analogous with that of the Ascidian mollusk? Keeping before us the antithesis between sensori-motor and intelligent action, we are to attempt to open a path through the mass of complications presented by observation of the conduct of animals. As intelligence is commonly attributed to the higher animals, it becomes needful to include it here, accepting the facts of human life as a test for judgment when the actions of animals are brought under review. It must, however, be misleading and scientifically unwarrantable, to proceed, as Dr. W. Lauder Lindsay has done, to apply the abstract terms descriptive of the mental activity of man to the conduct of animals.[1] Our only legitimate course must be to attempt rigid discrimination between sensori-motor activity and action of intelligence.

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[1] *Mental Physiology*, p. 45.

[2] *Ibid.* pp. 45, 46.

6. When, in the ascending scale of animal life, Intelligence appears, it must be accounted for either by proving that, under certain conditions peculiar to higher organisms, sensori-motor apparatus is capable of fulfilling higher functions, or by referring to something within the organism (or, it may be, beyond the organism) superior to sensori-motor apparatus.

7. The avenue for discovery concerning the manifestation of Intelligence in animals must be primarily the functions of the sensory system, and only in a secondary way the functions of the motor system, as these indirectly illustrate action of Intelligence. The sensory system, as it is, by functional activity of every one of its fibres, discriminative, is the natural organic line towards that phase of discrimination implying intelligence. The sensory fibre has its several varieties of molecular motion according to the force of impact, and differences in the surface of the body brought into contact with the touch corpuscle or other peripheral organ. Intelligence perceives the differences between present and past impressions, compares them, and draws inferences according to likeness or unlikeness. If, then, sensory fibre does not itself distinguish differences,

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[1] *Mind in the Lower Animals*, by W. L. Lindsay, M.D. 2 vols.

its functional action involves diversity of impression, thus presenting materials for intelligence, and affording the pathway for fuller interpretation of intelligent discrimination. Professor Bastian recognises this special relation, but goes too far in proposing altogether to exclude motor activity. He says, "We should include as 'mental phenomena' the functional results of all nerve actions on the side of ingoing currents, and in the nerve centres." But he adds, "The functional results of outgoing currents lie wholly beyond the sphere of mind."[1] The sensory system is certainly the natural avenue toward interpretation of Intelligence, but exclusion of the motor apparatus would be inconsistent with full recognition of the unity of the nerve system, and would sacrifice an important branch of evidence concerning intelligence. While, on the one hand, motion continued from a sensory nerve into a motor nerve illustrates non-intelligent action; on the other, motor activity, independent of sensory impulse, or antagonistic to it, may illustrate intelligent action. It is, therefore, impossible to exclude outgoing currents from available testimony as to action of intelligence.

Here, however, the radical distinction between sensori-motor activity, and activity directed by intelligence, must be rigidly held. For it is just at this point that ambiguity and inconsistency of argument are allowed to appear in scientific discussion. For example, Dr. Bastian proposes, in the above quotation, to include the whole functional results of the ingoing nerves as "mental phenomena." And Professor Huxley, when presenting the opposite alternatives of "soul" or "no soul," states that, under the former alternative, "the phenomena of the senses are purely spiritual affections."[2] These two suggestions, so far from being warranted, are, in one important aspect, inconsistent with the surest results of scientific research. This must here be made perfectly clear, as it involves a vital point in the argument, while the facts are beyond dispute. Sensory activity, and motor activity, and sensori-motor activity, are all examples of purely mechanical action, and in themselves afford no evidence of the action of intelligence. As Professor Huxley says, "the living body is a mechanism," and this is the "fundamental proposition of the whole doctrine of scientific physiology." "The movements of animals are due to the change of form of muscles, which shorten and become thicker; and this change of form in a muscle arises from a motion of the substance contained within the nerves which go to the muscle." "The motion of the matter of a sensory nerve may be transmitted through the brain to motor nerves, and thereby give rise to contraction of the muscles to which these motor nerves are distributed; and this reflection of motion from a sensory into a motor nerve may take place without volition, or even contrary to it." "The spinal cord, apart from the brain, has been proved to be a great centre of reflex action." This fundamental conception of reflex activity "is one of the pillars of nerve physiology at the present day."[1] Accordingly, using once more the words of Professor Huxley,[2] even those maintaining that "consciousness is the function of a something distinct from the brain, which we call the soul," must hold that "the phenomena of the senses," properly so called, are purely mechanical actions. "Mind" and "soul" and "mental phenomena" are here unwarrantably because prematurely introduced, there being in sensori-motor activity no action other than that of nerve apparatus.

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[1] *The Brain as an Organ of Mind*, by Dr. H. C. Bastian, pp. 148, 149.

[2] *Science and Culture*, p. 209.

The source of the ambiguity and perplexity arising from introduction of these terms is manifest. It is want of rigid analysis, or neglect of its full value when reasoning as to the action of the sensory or motor nerves. The ambiguity lies in Dr. Bastian's use of "results," and in Dr. Huxley's use of "phenomena." When the former says, "we should include as 'mental phenomena' the *functional results* of all nerve actions on the side of ingoing currents, and in the nerve centres," he is thinking of what we mean by "sensations," and is treating these sensations as functional results, whereas, as Professor Huxley shows, the functional results properly so called, are forms of motion. "Modern physiology amends Descartes' conception of the mode of action of sensory nerves in detail, by showing that their structure is the same as that of motor nerves; and that the changes which take place in them, when the sensory organs with which they are connected are excited, are of just the same nature as those which occur in motor nerves, when the muscles to which they are distributed are made to contract: there is a molecular change, which, in the case of the sensory nerves, is propagated towards the brain."[1] This is the entire physiological result yet ascertained, the peripheral organ is excited, and motion results, which may either be propagated to the brain only, or may pass on to the motor nerve and the muscular system. But Professor Huxley falls into the same ambiguity when he suggests that those who hold to a separate existence of soul must regard "the phenomena of the senses as purely spiritual affections." Here also the reference is to sensations, whereas "the phenomena of the senses" are excitation of the peripheral organ, and consequent movement of the nerve fibre and nerve cell. Whether animals have sensations such as we have, and whether they are conscious as we are, it is impossible to tell; but to this we must hold as scientifically established concerning all organic life, that excitation of the sensory organ, molecular movement within the sensory nerve fibre, movement within sensory and motor cells, and within motor nerves, and movement of muscles, are all mechanical, non-intelligent actions. It is scientifically inadmissible to include these movements among mental phenomena. They are not "mental," not "spiritual," inasmuch as they are mechanical.

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[1] Huxley's *Science and Culture*, pp. 199, 205, 210, 211. [2] *Ib.* p. 209.

With these facts before us, it remains nevertheless true that it must be through study of the sensory system that we seek interpretation of animal intelligence as generally acknowledged among us.

8. Accepting popular representations as to animal intelligence, it seems clear that animals credited with marked intelligence possess special forms or degrees of sensibility, provided for either by terminal organs of peculiar sensitiveness, or by high development in the cerebral region of apparatus connected with one or more of the special senses. This is the most general induction, based on ample evidence, apart from minute inquiries as to the nature of intelligence. No scientific theory of animal intelligence can be constructed which does not make account of this fact.

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[1] Huxley's *Science and Culture*, p. 208.

The first illustration of the law introduces us to the Ant, which presents the grand puzzle in the attempt to explain animal intelligence. The small brain and great intelligence of the animal have proved a source of perplexity, from which no escape has yet been suggested. But, when attention is turned from its brain structure to its special organs of sensibility, new light is shed on the puzzle, and a proportionate modification of theory becomes needful. The antennae or feelers of insects are among the most sensitive organs in nature, though on account of their minuteness, interpretation of their functional activity is peculiarly difficult.

Most interesting evidence can be gathered from observations of the smaller and more delicate flies. We must, however, concentrate attention here on the ant. In this comparatively small animal, intelligence is great, and the brain is a mere thin line, but the antennae are distinguished by marvellous sensitiveness. Huber, Müller, Moggridge, Darwin, M'Cook, Lubbock, and many more, have given evidence extensive and varied as to the high intelligence of ants. There is division of labour among them, there being males, females, and neuters or workers without wings, which do all the duties of carrying out and in the larvae and pupae, and carrying in stores to the nests. Memory of places, of objects known before, and of works they have begun, is great in ants. Their construction of galleries, and education of larvae, give further proofs of intelligence. More recent testimony is still more surprising. Ants stroke the aphides to obtain their honey, as we use cows to obtain milk (Darwin's *Origin of Species*, 6th edition, p. 207); one species keeps slaves to work for them (*ib.* 217); some species carry on agricultural operations, clearing away the long grass around their nests, and cutting paths through it; they construct galleries for storehouses, gather, carry in, and store dried seeds; and when stored seeds are wet with rain, they are brought out, dried in the sun and stored again (H. C. M'Cook's *Agricultural Ant of Texas;* and Moggridge's *Harvesting Ants of the Riviera*). In the records of animal life, the equals of the ants in certain phases of intelligence are not to be found.[1]

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[1] For a careful summary of evidence as to the intelligence of the Ant, *vide* Romanes's *Animal Intelligence*, pp. 31-142.

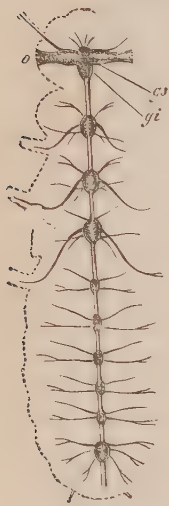

FIG. 42.—NERVE SYSTEM OF A WHITE ANT.—(*Termes.*) *o*, eye; *gs*, brain; *gi*, sub-œsophageal ganglion.[1]

The ant is an articulated animal, with a succession of nerve centres as in the bee, wasp, and other insects. Prominence is given to the upper nerve centre, which is elongated in form, constituting the brain proper. Müller has shown that the subordinate centres do not fulfil the functions of brain, but provide for sensori-motor action, such as may be seen in cases where an insect has been decapitated, and action of the nerve fibres continues after severance of the parts. The nerve centre in the head (the brain proper) is connected with the eyes, antennae or feelers, the tongue and other parts of the mouth, all of which are closely related with the functions of the brain. Dujardin remarks that "one cannot weigh the brain of an insect, which would be a fraction of a millogramme." Hence we must proceed by comparison of bulk of brain with bulk of body, for the slightness of the organ is such that it can with difficulty be touched, being soft, pulpy, and translucent. It is imbedded within the arrangements of the salivary glands, windpipes, and wind-bags, placed around it "like a cushion full of air, sustaining and protecting the organ." In the brain of all insects, there is a pulpy or cortical substance enclosing more or less detailed arrangements, including globules, peduncular bodies, and tubercles. Dujardin says that the less intelligence shown, the more there is of the pulpy substance; the more intelligence, the less of the pulpy substance, and the greater the apparent detail of inner structure. In neuter ants, which are the workers, and do not produce young, the pulpy substance has almost disappeared, and the separate centres or lobes for the antennae, and the network of the eyes, are more marked. Within the brain are two peduncular bodies, and radiated discs like convolutions, and there are two tubercles, the one travelling inwards and combining the two parts of the brain, the other travelling outwards to the surface. It is this outer part of the tubercle which the ants touch with their antennae or feelers, when they communicate to one another as to work to be done. After this account of the structure, Dujardin adds: "Thus there are in the brains of insects parts which appear more specially connected with the intellectual faculties." (*Annales des Sciences Naturelles,* third series, xiv. 195.) It is plain, then, that there is differentiation even within the very small body we call the brain of the ant, and distinct features, though minute and difficult to discern, homologous in structure and function with those of the more elaborate centres of the vertebrates. The brain of the bee is, however, very similar to that of the ant, yet the bee is inferior in intelligence.

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[1] Gegenbaur, after Lespès. From Bastian's *Brain as Organ of Mind.*

If from the brain of the ant we turn to the accounts of the astonishing activity of different orders of ants, we are at once convinced of the perplexity connected with their interpretation, for the intelligence of the ant is more surprising than that of the dog, monkey, or ape. No one of the three, even under the most favourable conditions, approaches the detail of purposive activity accomplished by this animal, so comparatively insignificant that it would be crushed by a slight pressure of the foot of any of the other three. One thing seems clear the longer this case is pondered, that in our study of the intelligence of animals, we have hitherto given too little heed to the instrument of knowledge in use. The antenna of the ant surpasses in sensibility anything at command of the higher animals, or even of man.[1] The ant is the animal most highly endowed with sense of touch. Its antennae are not only the prominent guiding organs, as in the case of insects generally, but are rendered peculiarly sensitive by the addition of delicate hair-lines spread over their surface, and are besides articulated to a degree which provides for a great variety of movement in using this discriminating organ. The hand of man cannot approach the delicacy of touch possible to the antennae of the ant. Besides this, there is a complicated structure of the leg enabling the animal not only to grasp objects tightly, but to take a variety of positions hardly possible to any other animal. A glance at the figures will enable the reader to judge of the peculiarities of structure, and the special advantages of the ant in its organs of sensibility in comparison with any other one of the animals noted for intelligence. Neither the dog nor the horse, the monkey nor the ape has an organ of such sensibility at command.

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[1] See M'Cook's *Agricultural Ant of Texas*, plates 14, 16, 19. M'Cook's *Honey Ants and Occident Ants*, plate 7. For analogy, see Antennae of the Blow-fly, plate VIII., in Lowne's *Anatomy and Physiology of the Blow-fly.*

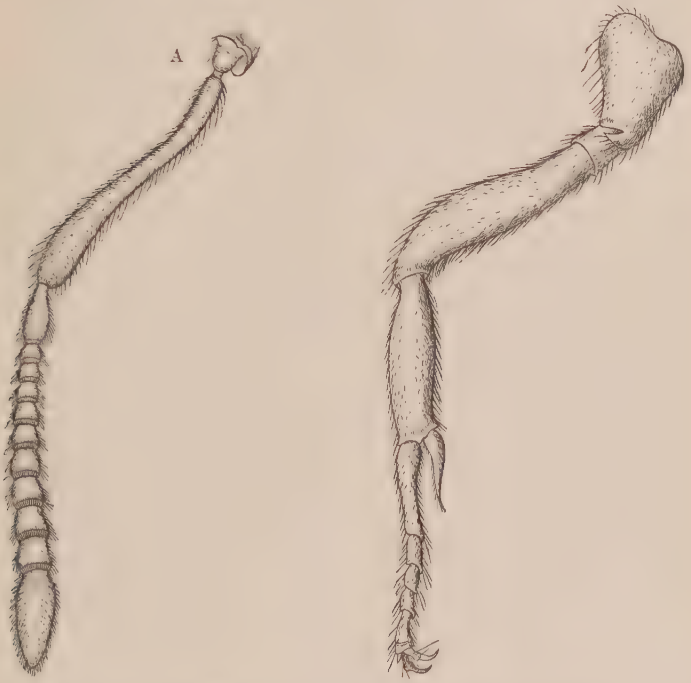

FIG. 43.—A, ANTENNA OF THE ANT, MAGNIFIED 25 TIMES.
B, LEG, MAGNIFIED 20 TIMES.

(Drawn by Professor J. Cossar Ewart, Edinburgh, from a specimen of the House Ant, *Myrmica.*)

That the antennae are the principal organs of discrimination in the busy life of these active creatures admits of no doubt. Ants are not distinguished for acuteness in the other special senses. Even if, as has been supposed, the antennae include the organs of smell, the animals are not specially gifted in this respect,—they are hardly affected by sound,—and many of them have a decided preference for a dark retreat. But testimony is decided as to the value of the antennae. "Their removal produces an extraordinary disturbance in the intelligence of the animal. An ant so mutilated can no longer find its way or recognise companions. . . . It is also unable to find food, ceases to engage in any labour, and loses all its regard for larvae, remaining permanently quiet, and almost motionless" (Romanes's *Animal Intelligence*, p. 142). Perusal of this statement, which is fully supported by evidence, recalls the descriptions of consequences attending on removal of the frontal lobes from the brain of higher animals. The analogy is so close as to suggest that the antennae of the ant, with a brain adequate for their functional requirements, are equivalent to the most important parts of the brain of higher animals, working with inferior sensory apparatus. Such organs of sensibility as those possessed by ants are a specialty in sensory organism,—a conspicuous illustration of sensory power concentrated in an external organ of touch. Deprived of its antennae, the ant is "stupid;" their loss is equivalent to the "destruction of the mental faculties."

How, then, shall we interpret the functions of the antennae? And how far may such interpretation include the indications of intelligence? The short answer, no antennae, no intelligence, will not suffice. But the testimony as to the results of loss of the antennae is of great value, suggesting that the sensibility of the external organs is the origin of action concerned with finding of food, sense of direction, recognition of friends, and many other recorded acts, all of which may on this ground be regarded as sensori-motor. Still, we must interpret in view of direct evidence as to the ordinary uses of the antennae. Huber describes the consternation of ants when he scattered fragments of their nests on his floor in which they could find no chink introducing to a darkened cavity. Such an opening having been at length discovered, the fortunate ant "returned to its companions, and, by means of certain movements with its antennae, imparted to them the joyful intelligence." These became guides, and "every time they met, they stopped and struck each other with their antennae in a very remarkable manner, and appeared fully instructed of the route they should take" (Huber's *Natural History of Ants*, Johnson's Transl., p. 154). In accordance with this, Huber writes an interesting section on "The Antennal language," in which he says that "the antennae, the organs of touch, and, perhaps, of some other sense which is unknown to us, are the principal instruments connected with the language of ants," adding that "their situation in the fore part of the head, their flexibility, their construction, which presents a series of articulations, endowed with extreme sensibility," induce him to believe "that the antennae perform the most important office among ants" (*Ib.* p. 206). Kirby and Spence are equally explicit. "Those remarkable organs, their antennae, are the principal instruments of their speech, if I may so call it, supplying the place both of voice and words. When the military ants go upon their expeditions, and are out of the formicary, previously to setting off, they touch each other on the trunk with their antennae and forehead:—this is the signal for marching, for as soon as any one has received it, he is immediately in motion." (*Introduction to Entomology*, Kirby and Spence, seventh edition, p. 324.) Again, speaking of the rufescent ants, and referring to Huber and Latreille, they say, "Like dogs with their noses, they explore the ground with their antennae to detect the traces of the game they are pursuing." (*Ib.* p. 330.) Huber also describes the sports of the ants, when they "approach each other, moving their antennae with astonishing rapidity; with their fore feet they patted lightly the cheeks of other ants; after these first gestures, which resembled caresses, they reared upon their hind legs by pairs; they wrestled together." (*Ib.* p. 346.) These illustrations may suffice to show how rapid and varied are the movements of the antennae; how largely the phases of intelligence attributed to the ants are dependent on these organs; and how completely their habits harmonise with the observation of Dujardin, that communication is made by tapping a point on the forehead where a tubercle of the brain is brought to the surface.

What is next required to complete this view is, reliable testimony as to what ants cannot do,—evidence as to poverty of intellect, by the aid of which our conceptions may be better tested and adjusted. For this we are specially indebted to Sir John Lubbock, who has distinguished himself as a most careful observer, and ingenious experimenter. His experiments were designed to ascertain the inventiveness of ants, or power to overcome unexpected difficulties, in view of the facts that their sense of direction is strong, and their aptness great in shifting the angles of bodies difficult to drag into their nests. In one case, when the ants were in full activity, he opened a chasm of half an inch on their road home, which had either to be crossed, or a roundabout course of seven feet had to be taken over sticks laid for them. "Though the ants reached over, and showed a great anxiety to take this short cut home, none of them faced the leap, but all went round by the sticks" (*Journal of Linn. Soc. Zool.* vol. xii. p. 486). Again, the ants were tried by being led down a slope towards the food they were in search of, leaving only three-tenths of an inch as a venture from which they might descend on the coveted prize. "It did not occur to them to drop three-tenths of an inch" (*Ib.* vol. xiii. p. 217). Again, larvae were placed in a cup, on a slip of glass, surrounded by water, but made accessible to the ants by a paper bridge. This bridge was drawn back a little, so as to leave a chasm they could not reach across. "It did not occur to them to push the paper bridge, and after a quarter of an hour's attempt, they gave it up." The result proved the same when a bit of straw was substituted for the paper (*Ib.* p. 218). The conclusions from these experiments are important. These animals, dependent mainly on sense of touch, naturally shrink from effort when this sense seems to fail them; and they show themselves incapable of such exercise of intelligence as would be implied in slight adaptation of means for meeting difficulties with which they are unfamiliar. These examples are the more striking inasmuch as certain species of ants make bridges by clinging to each other by their mandibles and feet: while lack of courage cannot be suggested of animals that suffer themselves to be torn to pieces rather than relax their grasp on a foe. Finally, communication from one ant to others as to stores of food, does not involve communication of plan of action, or of direction to be followed. When an ant went to the nest, she brought out eight or ten companions; but when she was lifted up, they could not find their way; after wandering around vainly, all returned to their nest. (*Ib.* p. 219.)

On a survey of the evidence now submitted, it seems impossible to claim for any animal a higher degree of intelligence than for the ant. If this be considered doubtful, and a plea for superiority be made, for example, in behalf of the dog, the debatableness of this plea is sufficient proof that a singularly high intelligence belongs to the insect. The comparison of two animals so unlike may aid us in our appreciation of the problem in neurology; and this all the more that the dog is capable of doing so many things which the ant cannot attempt, while the ant can do much for which the dog is altogether unequal.

Comparison of the two brains means contrast. It is not similarity, but difference which is most apparent. The brain of an ant is a mere point, which hardly admits of being handled; the brain of the dog is a complex structure, the whole internal arrangement of which is closely analogous to that of man. In view of this difference, along with the possible comparisons as to intelligence, we readily assent to the statement of Darwin, that "the brain of an ant is one of the most marvellous atoms in the world, perhaps more so than the brain of a man." That such an "atom" should prove adequate for the manifestation of so much intelligence is indeed a marvel; and a serious perplexity, if it be maintained that intelligence is proportionate to brain structure. Pushing our comparison further, we find that the ant's brain, atom though it be, shows a measure of differentiation, having distinguishable parts connected with the antennae, mouth, and network of the eyes. But, in observing the functions of this brain, we do not distinguish smaller cells from giant pyramidal cells, which have been named "mind cells." Here it seems needful to admit the existence of high intelligence, without being able to trace giant pyramidal cells as necessary for its exercise.

Suppose now we alter the point of view, taking the sensori-motor system as the key to the situation, regarding the brain in each case as only the governing centre of this system, while the sensory organs are the real test of intelligence or power of discrimination. The harmony of structure and function at once becomes greatly more simple, and our theory more rational. The comparative points of superiority in the respective animals become plain. The ant is immensely superior to the dog in the sense of touch, and in this way, though restricted to a comparatively narrow field of action, it has a power of discrimination unknown to the dog, having a knowledge of plants, and seeds, and of kindred orders of insect life, of which the dog knows nothing, and is incapable of knowing anything. To a dog, an ant is only a moving object, capable of biting; to an ant itself, the different orders of ants to which individuals belong is matter of liveliest interest. The dog has, no doubt, a greatly higher brain; but it has not at command such an organ of touch as the smaller animal possesses; and, on this account, notwithstanding superiority of brain, the dog must remain ignorant of much that is familiar to the ant. So, in like manner, the ant passes by objects as if they had no existence, which engage a large amount of a dog's interest. This difference explains the fact that it is a debatable point, whether the intelligence of the ant or of the dog is the higher. The sensory organs at command are so different that there are many respects in which they cannot be compared.

We are thus guided to a definite conclusion as to the intelligence of the ant. The external sensory organs afford the key. These organs are a speciality in animal life, and the ant's intelligence is in keeping with the recognised functions of the organs of discrimination at its command. It is in accordance with this view that the brain of the bee is said to be similar to that of the ant, while the bee is inferior in intelligence, for it is greatly inferior in the functional power of its antennae, as its modes of life are altogether different. The key to the preeminence of the ant is thus clearly identified. The mystery as to its instinct remains what it was; the puzzle as to its intelligence disappears. The craving of hunger must in all animals explain the search for food; the antennae of the ant explain only power of discrimination as this search proceeds. So it must be with all the characteristics of different orders of ants, in accordance with which they are gregarious and social, relieve one another in difficulty, unite in constructing formicaries, and in some cases gather, dry, and store seeds. All this must be regarded as instinctive, for, as Darwin has said, "instincts are as important as corporeal structures for the welfare of each species" (*Origin of Species*, 6th ed., p. 206). But the ant's wonderful power of discrimination is accounted for by its wonderful power of touch. With the ant it seems as if sight, hearing, and even language itself were concentrated in the one sense of Touch. This ascertained, it follows that this high degree of sensibility is attended by motor activity, which commonly bears some proportion to the sensory side of the nerve system. In harmony with this conclusion, concentrating its chief intellectual power in sense of touch, are the ascertained facts as to the ant's incapacity for overcoming what seem to us slight difficulties; and also the recorded results of loss of the antennae.

It remains only that the general conclusion be emphasised as bearing on comparative intelligence in relation to nerve organisation. In animal life, power of discrimination is largely determined by the range of sensibility belonging to external organs of sense. It is therefore essential for clearness of discussion in neurology, that these things be noted; that in all animals, the sensory nerves are fundamentally the same; but the outward organs connected with the sensory system vary greatly in complexity of structure, and these variations involve proportionate differences in capacity for discrimination.

Next, let us turn to the CHICK. This selection is made, not because of the intelligence of the animal, but rather for an opposite reason; for, if a theory is to be constructed on the results of comparative neurology, attention must not be concentrated exclusively on the most favourable examples of animal intelligence. An additional reason for this selection is that all the facts connected with the development of the animal are well known, and have been made the subject of special investigation. The successive stages of the development of the head of a chick are presented in a series of figures in Professor Huxley's *Anatomy of Vertebrated Animals*, p. 16, showing well the relative importance of the sensory organs.[1] This organism illustrates concentration mainly on the optic tract. The organ of hearing is also comparatively well developed; the olfactory tract is slight; and there is very little of what can be regarded as an organ of touch. The structure of the nerve system thus presents a striking contrast to that of the ant. The chick is completely shut off from the large range of tactile impression with which the ant is familiar; and on the other hand it has a power of vision to which the ant is an utter stranger. The whole question of intelligence is affected accordingly; and by observations of the chick we are placed in an advantageous position for estimating the intellectual value of sensory apparatus. The eyes are so largely developed as to be, on the sixth day, quite the outstanding feature of the head. Our chief interest, therefore, concentrates on the possibilities of a life regulated by vision, the organ for which is sustained by correlation with a strong sense of hearing. Mr. Douglas A. Spalding instituted careful experiments on chicks, from the moment of their breaking through the shell, with the view of ascertaining whether their use of vision, involving knowledge of distance, and of direction, and of amount of motor force required to reach an object, could be supposed dependent in some degree on training. The results are recorded in the following statement:—"Taking eggs just when the little prisoners had begun to break their way out, I removed a piece of the shell, and before they had opened their eyes drew over their heads little hoods, which, being furnished with an elastic thread at the lower end, fitted close round their necks. The material of these hoods was in some cases such as to keep the wearers in total darkness; in other instances it was semi-transparent. Some of them were close at the upper end, others had a small aperture bound with an elastic thread, which held tight round the base of the bill. In this state of blindness—the blindness was very manifest—I allowed them to remain from one to three days. The conditions under which these little victims of human curiosity were first permitted to see the light were then carefully prepared. Frequently the interesting little subject was unhooded on the centre of a table covered with a large sheet of white paper, on which a few small insects, dead and alive, had been placed. From that instant every movement, with the date thereof, as shown by the watch, was put on record. This experiment was performed on twenty separate chickens at different times, with the following results. Almost invariably they seemed a little stunned by the light, remained motionless for several minutes, and continued for some time less active than before they were unhooded. Their behaviour, however, was in every case conclusive against the theory that the perceptions of distance and direction by the eye are the result of experience, of associations formed in the history of each individual life. Often at the end of two minutes they followed with their eyes the movements of crawling insects, turning their heads with all the precision of an old fowl. In from two to fifteen minutes they pecked at some speck or insect, showing not merely an instinctive perception of distance, but an original ability to judge, to measure distance, with something like infallible accuracy. They did not attempt to seize things beyond their reach, as babies are said to grasp at the moon; and they may be said to have invariably hit the objects at which they struck—they never missed by more than a hair's-breadth, and that, too, when the specks at which they aimed were no bigger, and less visible, than the smallest dot of an *i*. To seize between the points of the mandibles at the very instant of striking seemed a more difficult operation. I have seen a chicken seize and swallow an insect at the first attempt; most frequently, however, they struck five or six times, lifting once or twice before they succeeded in swallowing their first food." "A chicken that had been made the subject of experiments on hearing, was unhooded when nearly three days old. For six minutes it sat chirping and looking about it; at the end of that time it followed with its head and eyes the movements of a fly twelve inches distant; at ten minutes it made a peck at its own toes, and the next instant it made a vigorous dart at the fly, which had come within reach of its neck, and seized and swallowed it at the first stroke; for seven minutes more it sat calling and looking about it, when a hive-bee coming sufficiently near was seized at a dart and thrown some distance, much disabled. For twenty minutes it sat on the spot where its eyes had been unveiled without attempting to walk a step. It was then placed on rough ground within sight and call of a hen with a brood of its own age. After standing chirping for about a minute, it started off towards the hen, displaying as keen a perception of the qualities of the outer world as it was ever likely to possess in after life. It never required to knock its head against a stone to discover that there was 'no road that way.' It leaped over the smaller obstacles that lay in its path and ran round the larger, reaching the mother in as nearly a straight line as the nature of the ground would permit. This, let it be remembered, was the first time it had ever walked by sight." Mr. Spalding has also subjected chicks to experiment, with the view of ascertaining how far they are guided by sight, how far by hearing, in following the hen. He concludes that sight is not their guide in this. "Chickens as soon as they are able to walk will follow any moving object. And, when guided by sight alone, they seem to have no more disposition to follow a hen than to follow a duck, or a human being." That the sound of the hen's cry is their guide seems conclusively established. "Chickens hatched and kept in a flannel bag for a day or two, when taken out and placed nine or ten feet from a box in which a hen with chicks was concealed, after standing for a minute or two, uniformly set off straight for the box in answer to the call of the hen, which they had never seen and never before heard. This they did, struggling through grass and over rough ground, when not yet able to stand steadily on their legs. Nine chickens were thus experimented upon, and each individual gave the same positive results, running to the box scores of times, and from every possible position." (*Macmillan's Magazine*, Feb. 1873.) These results are of much value for interpretation of possibilities of sensory apparatus. Here, as with the ant, the instincts of the animal are presupposed, nothing in the action of the sensory apparatus explaining these. That instincts are inherited possessions, is confirmed by observations as to experience of fear at presence of a hawk, the chick at sight of it giving the chirr expressive of danger; while the shrill chirp of the hawk is immediately followed by concealment of the chick under the nearest cover. Allowing, then, for instinct as inherited possession, the actions of the chick are the immediate result of sensory impressions, either optic or auditory. Interposition of intelligence is set aside in the most conclusive manner, inasmuch as experience and training are excluded. This fact is all the more important as evidence on which to base our conclusions, because it is admitted as being beyond dispute that a child acquires knowledge of direction, distance, and proportionate muscular exertion, by use of intelligence, obtaining only by slow acquirement what the chick has at command from the first. This contrast is all the more striking on account of the commonplace life of the barn-door fowl, to which popular judgment does not assign any high degree of intelligence. In the chick we see the possibilities of a highly developed optic tract, aided by a well-formed auditory tract, in providing for a promptitude of action unattainable by an intelligent being, who has at command sensory apparatus, not only equal, but even superior. This example of the organisation of brain and nerve clearly demonstrates the importance of having our observations turned upon animals not specially noted for intelligence. In these cases there seems an organic isolation of sensory and motor phenomena, from those more naturally described as phenomena of intelligence; and such isolation gives greater simplicity and certainty to our reading of the facts of neurology. By means of an entirely different sensory tract, so situated that the sensory apparatus is in closer relation with the brain, and consequently less under the notice of an observer, the position is confirmed that many forms of action in animal life attributed to intelligence, and which in the life of man are not performed without intelligence, are accomplished solely by mechanical or sensori-motor apparatus.

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[1] For full details of Evolution of the Chick, see *Elements of Embryology*, by Foster and Balfour, from p. 13 onwards.

We have now seen animal intelligence under two phases, the one dependent on the sense of touch, the other on sight and hearing; and, though in human life, we properly regard sight as "the most intellectual of the senses," we have seen that an animal guided by Sight is lower intellectually than an animal directed by touch. The next step involves a further disturbance of our familiar classifications of the senses. For Smell appears the leading feature in the sensory system, and it is often connected with a high degree of intelligence. Professor Bain remarks that the senses may be divided "into two classes, according to their importance in the operations of the Intellect," for Taste and Smell "contribute little of the permanent forms and imagery employed in our Intellectual processes," this last function being "mainly served by Touch, Hearing, and Sight, which may therefore be called the Intellectual senses by pre-eminence." (*Senses and Intellect*, second ed., p. 119.) Such a division of the senses is appropriate when human life is considered, but it needs to be readjusted in a singular manner when, under guidance of comparative neurology, we contemplate animal intelligence. Both in the DOG and in the HORSE, to which we now turn, the olfactory apparatus is the most prominent organ of special sense, and it is associated with a more elaborate brain. The Dog and the Horse are certainly popularly regarded as the most intelligent of all animals, and yet the discriminating power on which they are most dependent is that of smell, supported by sight and hearing, but hardly at all aided by touch. This combination requires special attention. In the ascending scale of animal life, the transition to the mammalia is marked by great prominence of the olfactory tract, along with steadily increasing complexity of brain. This is well illustrated both in itself, and by contrast with the ape, in Professor Huxley's figures of the brain of the rabbit, pig, and chimpanzee, placed together on the same page,[1] these figures being designed to show progress from the smooth brain to the convoluted. The proportion of the olfactory bulb in the mammalia specially engaged the study of M. Broca, who distinguishes mammals and brains as smelling and non-smelling (*osmatique* and *anosmatique*).[2] A comparison of the lower surface of the Dog's brain with that of the human brain will place the contrast in a striking light. Compare also lateral view of Dog's brain, Fig. 32, p. 134; and base of Human brain, Fig. 12, p. 34.

In the ascending scale of organisms, attention is here apt to be concentrated on the increase of the convolutions of the cerebrum; whereas in the study of animal intelligence, the first place must be given to comparative sensory apparatus, while keeping in view growing complexity in the governing organ. The Ant is mainly dependent on Touch, having comparatively

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[1] *The Anatomy of Vertebrated Animals*, p. 61.

[2] Anatomie comparée des Circonvolutions Cérébrales, par Paul Broca, *Revue d'Anthropologie*, 1878.

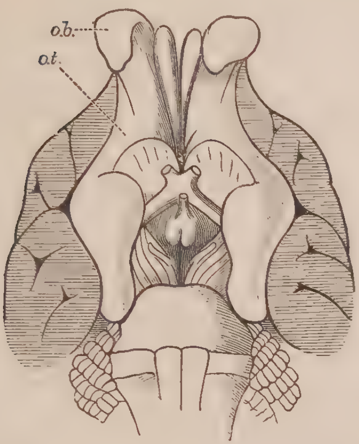

FIG. 44.—LOWER SURFACE OF THE DOG'S BRAIN, SHOWING OLFACTORY TRACT.
(After example in Schwalbe's *Lehrbuch der Neurologie*, p. 531, slightly reduced.)
o.b., olfactory bulb; *o.t.*, olfactory tract.

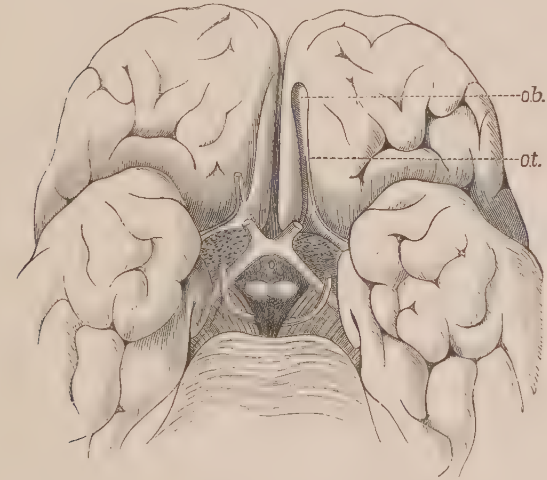

FIG. 45.—FORWARD PART OF THE LOWER SURFACE OF THE HUMAN BRAIN, SHOWING OLFACTORY TRACT.
(Reduced from example in Schwalbe's *Lehrbuch der Neurologie*, p. 474.)
o.b., olfactory bulb; *o.t.*, olfactory tract.

little aid from other senses; the Chick is guided, as are fishes and birds generally, by Sight and Hearing, hardly at all by touch, slightly by smell; the Dog is directed largely by Smell, while sight and hearing are both active, but a specially sensitive touch apparatus does not exist. We have now, therefore, to consider the predominance of Smell as an instrument of discrimination in the case of the dog, and afterwards we shall pass to the monkey and ape, in both of which the sensory organisation is after the type of the human brain.

In the dog's brain, as appears on fig. 44, the olfactory apparatus is very highly developed; in the human brain, fig. 45, it is greatly inferior. A glance at the bulb and tract as shown in the figure of the dog's brain will convince the reader how much we are apt to be misled when speaking of the *nerves* of special sense. In this case, instead of speaking of olfactory nerves, or allowing ourselves to think of the olfactory apparatus from the analogy of nerve fibres as spread over the body, we shall have safer guidance if we describe the olfactory and optic nerves in the terms chosen by Professor Huxley, as "more properly diverticula of the brain" (*Anat. of Verteb. Animals*, p. 66). These masses are really portions of the brain. The olfactory bulb stands out prominently in front, and is even more powerful in the brain of the horse, as will appear by reference to fig. 34, p. 141, and still more from the figure of the horse's brain in M. Broca's Anatomie comparée des Circonvolutions Cérébrales, *Revue d'Anthropologie*, 1878, p. 420, taken from *Anatomie comparée des Animaux Domestiques*, par MM. Chauveau and Arloing. From the bulb are given out the nervous filaments spread over the mucous membrane of the nostrils in elaborate ramifications (as described above, p. 59); by these the nostrils are rendered sensitive to odorous particles floating in the atmosphere. From this bulb, there passes back under the surface of each hemisphere a tract or peduncle composed of the nerve fibres which connect the bulb with the cerebrum. How numerous these fibres are will appear from the breadth of the tract as shown in the dog's brain, fig. 44. The roots of the olfactory tract, where the fibres pass upwards to the brain, are found towards the rear of the frontal lobe, at the smooth part sometimes named

Broca's lobe, of which he specially treated under the designation *le grand lobe limbique*, and towards the lower extremity of the temporo-sphenoidal lobe, the fibres partly crossing the Sylvian fissure.[1]

We have now to consider the degree of intelligence manifested by the dog and horse. These being our most familiar domesticated animals, there is general acquaintance with the phases of intelligence commonly exercised by them. Nevertheless we experience much disadvantage here from absence of carefully recorded observations and experiments. Those animals which, more than any other, are companions of man, and are therefore more generally under observation, have really been much less observed with needful precautions for isolation of individuals, and records of results, than animals more insignificant, and requiring much greater pains to observe their habits. Mr. Darwin by his special theory has roused interest and stimulated many observers whose several statements have been largely recorded. We have thus a considerable mass of testimony, but it has not been adjusted and verified with any approach to scientific precision.[2] Without casting discredit on the numerous anecdotes, it is manifest from the records that many of them can be accepted only with reserve, as not meeting scientific demands.

The requirements of the present investigation will be best satisfied by attempting an estimate, in the first instance, of the possibilities of the olfactory tract, aided by the optic apparatus. While carrying out this, and keeping in view the superior intelligence of the dog, it is needful to remember that predominance of the olfactory tract belongs also to the rabbit, otter, pig, cat, and ox, to none of which the popular judgment assigns high intelligence.

The sense of *Smell* is the usual guide of the dog as to *food*. In this respect it is on a common level with the other animals named, and in this connection we are not accustomed to attribute, even to the dog, high intelligence. Its characteristics as a feeder are in harmony with the original condition from which our dogs have been developed, any apparent diversity or modification of taste being the result of domestication. Odour, coming even from a great distance, and unobserved by us, attracts the dog. This involves discrimination of a wide range of objects not ordinarily included in human knowledge; in accordance with this, the world wears an aspect to the dog entirely different from the cosmos with which we are familiar; and if this difference may with propriety be expressed in terms of intelligence, the dog is more intelligent than man. There is a sense in which this is strictly accurate, and the fact deserves prominence; yet the unsuitableness of such language, if taken in the ordinary meaning applicable to human life, is manifest. When we consider the diversity of food chosen by the otter, the ox, and the dog, we do not attribute this diversity to intellectual qualities in the animals. The instincts of each species are different, and we are still without the theory of these instincts.

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[1] Broca, *Revue d'Anthropologie* (1878), p. 394; Huxley's *Anat. of Verteb. Animals*, p. 66; Ferrier's *Functions of the Brain*, p. 14.

[2] The numerous letters which have appeared in *Nature*, vol. xix. onwards, have supplied an extensive record of the more noteworthy achievements of our domesticated animals.

In close relation with the capabilities of smell in detecting the presence of food, must be taken the astonishing powers of the dog and horse, in recognising the direction to be followed, when travelling. Knowledge of direction is to a large extent involved in exercise of highly developed olfactory apparatus. The animal is thereby placed in a position of superiority, and is not dependent on our geographical and topographical knowledge, which it cannot acquire. It has a more simple and sure mode of guidance, which does not depend upon observation and intelligence. The contrast between the dog and the horse in the matter of food may help us here, and will show how small is the part intelligence performs in the superiority of these two when travelling through unknown country. Take the single illustration of the presence of game in the neighbouring brushwood or forest. This is matter of keen interest to the dog, while the horse cares nothing for it, living in an altitude of sublime indifference at least equal to that of the most absorbed surveyor of the geology of the district. The dog is the more "intelligent," the horse the more "philosophical," when "philosophy" means indifference. But the dog or horse will with ease find his home, or camp, or favourite resting-place, guided only by smell, and following a course never taken before. There is in both a delicate sensibility to odour, and prompt action under its guidance, which must always seem a marvel if estimated by the means of information at our command, depending as these do on intelligence properly so called, directed upon facts ascertained only by vision. The sensori-motor superiority of the animals gives them an enormous advantage over us in determining the course to be followed in unfamiliar country. There is thus illustrated the inferiority of intelligence as an instrument for guidance, on account of the slower methods it must use, in combining numerous points of comparison. To sensori-motor superiority, therefore, we must assign many of the wonderful stories as to dogs and horses, including all those which refer to a return home from great distances, over country never travelled before. To this class must be referred the "thoughtful sagacity" of the dog that found its own collar "partly buried in the tall grass" (*Nature*, xx. p. 220); the dexterity of the dog or horse finding its way home, or selecting camping ground; the wonderful feat of the ass shipwrecked in the Mediterranean, which swam ashore, and was in course of some days found at its stable door in Gibraltar. Hence the great confidence of travellers and sportsmen in the guidance of their horses. "The only two times in which I have really been lost—once in a very dense mountain-fog, the other time in a bad snow-storm—was owing to my doubting the proficiency of Boreas's [his horse's] path-finding abilities. On the first occasion I thought I knew the way better than he did, for I had been twice over the ground on foot, and he had only been once; while the other time I let my course be governed by my compass, rather than by the unmistakeable pulls to one side by which Boreas intimated his non-acquiescence with the direction. As it turned out, he was right and the compass wrong, the latter being unsettled by the presence of large masses of iron in the rocks. On both occasions I spent the night out at considerable altitude, and I can tell you that now I know better than to pull rein when once I am on the home track."[1]

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[1] *Camps in the Rockies*, by W. A. Baillie-Grohman, p. 97.

Besides power of smell, the dog and horse make large use of the sense of *sight*, as an auxiliary, and also as an independent guide. The dog resembles the chicken in its quickness of sight, though acquiring the use of its eyes more slowly. A dog is arrested and attracted by a moving object, just as the chick is. He will run barking at a moving wheel, or will go careering through a field after a railway train. These are examples of purely sensori-motor actions, giving no proof of intelligence, but rather of the want of it. On the other hand, a considerable measure of the dog's intelligence is to be explained through its sense of vision. Thus, in watching the movements of its master, it knows his figure, notices his expression, is affected by his changing looks; and, hearing coming to aid sight, the dog is influenced greatly by the tones of his voice. In all these respects the eye and ear act in a manner very similar to their functional activity in man; the horse shows considerable inferiority in these respects; the ox, in even a great degree. Beyond doubt, then, much of the dog's intelligence is connected with his use of sight; but very much of his annoying stupidity is also connected with his use of vision. He blunders in this as he never does in smell, a fact of the more importance here, inasmuch as sight requires higher exercise of intelligence for its full use than smell. Deficiency here certainly does not arise from defect in the organ of vision, for a dog is so quick in sight that he can pursue a bee with accuracy for a long distance; but it arises from inability to distinguish between objects when intelligence is required in order to do so. What the dog has been long familiar with, it recognises accurately; but it experiences great difficulty in regulating by sight its conduct towards objects not familiar, whereas it feels at once secure when allowed resort to smell. Thus in the dog's life, sight is only auxiliary to smell. In perplexity under visual impressions, the animal turns to an inferior sense, not to intelligence. The want of intelligence is here so conspicuous, that the dog's life is the antithesis of human life. Or, representing the facts by reference to sensory apparatus alone,—in the dog, sight is subordinate to smell; in man, smell is subordinate to sight.

The next point bearing on intelligence of the dog, is the absence of any distinct organ of touch. This is a conspicuous characteristic with the great proportion of mammalia, and must be taken as a prominent item in evidence. In the organism of the dog, the highest degree of sensibility is concentrated in his nostrils. The ordinary features of a sensory system belong to him, and his muscular sensibility is good; but he has not an organ of touch which could contribute largely to intelligence. The paw of the dog is not in any high degree a touch organ; still less is the hoof of the ox, or horse. The sense of touch, closely allied with intelligence, is one in which the dog is very deficient. The whole complex order of distinguishable impressions familiar to us by means of touch are unknown to him. Accordingly, he has little sense of form, proportion, and relative importance of material objects, such as conveys to us an extensive range of knowledge of the outer world.

We have thus before us a view both of the superiority and deficiency of sensory apparatus in the dog, and can thereby form some conception of the intelligence of the animal. Intelligent it is in respect of the discriminating power of smell; intelligent in a much less, though still considerable degree, in respect of sight; but hardly above the level of much lower orders in respect of touch, certainly far inferior in this to the ant.

With the distinctive sensory apparatus we must next connect an advanced or convoluted brain. The avenues of sense must in themselves, however, determine the possibilities of intelligence as to the outer world. Discrimination by the central organ cannot transcend distinctive experience through the sensory. This law must hold good for all intelligence, unless we are prepared to maintain the existence of intellect capable of some higher exercise than is involved in the discriminating power of sensory apparatus, that is, intelligence of such a nature as is required for interpretation of diverse sensory experience. To have the olfactory or optic tract excited, is one thing; to have a conception of the object is quite another thing. It therefore becomes essential to determine what are the functions of the superior brain of the dog, taken along with the functional activity of the sensory apparatus. First, the central organ fulfils all the ordinary functions of a nerve centre. Further, the more complicated brain provides for more complicated activity, which is, nevertheless, the same in functional character. For this, there is greater detail and intricacy of arrangement of fibres and cells. Take only the more extended olfactory apparatus, estimate the number of fibres composing it, and the various impressions possible to such an organ, calling for more abundant cellular tissue; thereafter, imagine the number of intra-cerebral fibres required for distribution of these impressions in accordance with the possibilities of the motor system, and the need for a more complicated nerve centre becomes apparent. No new function is implied in all this; and "intelligence," so far as it is involved, is nothing more than the discriminative and purposive action of mechanical apparatus.

In close relation with these phenomena, however, an additional feature of functional activity of brain calls for attention. This is capacity for retaining in brain tissue some impression from frequently repeated action of the same sensory apparatus. In accordance with what has already been said (pp. 55, 56) as to functional improvement through repeated use of sensory and motor nerves, there is an extension of the law of acquired facility to the brain, as the governing organ of the system. Human experience may afford illustration. As there is increased susceptibility of touch in the finger-points, and of motor action in the management of muscles, so is there extended activity in the brain itself. The one set of phenomena implies the other. What is thus true in human life can be shown to be so in animal life generally, but specially among the higher vertebrates. In brain tissue there is provision for increasing facility of action by repetition of exercise. There is thus in each individual life, growing familiarity with recurring impressions and actions, amounting to a phase of memory of past experience; and the same law applies on the motor side, preparing for greater possibilities in the future. Professor Huxley has clearly stated the facts, as bearing on reception of sensory impressions, in the following terms:—"The motion of any given portion of the matter of the brain excited by the motion of a sensory nerve, leaves behind a readiness to be moved in the same way in that part. Anything which resuscitates the motion gives rise to the appropriate feeling. This is the physical mechanism of memory."[1] Suggestions as to how this is accomplished are merely conjectures, such as the improbable one of Hartley, that "sensory vibrations, by being often repeated, beget, in the medullary substance of the brain, a disposition to diminutive vibrations." (Hartley, *On Man*, i. p. 58.) For, as Professor Huxley has said, "Physiology is at present incompetent to say anything positively about the matter, or to go further than the expression of the high probability, that every molecular change which gives rise to a state of consciousness, leaves a more or less persistent structural modification, through which the same molecular change may be regenerated by other agencies than the cause which first produced it."[2] Present knowledge warrants these conclusions, that recurring impressions along the same tract occasion modifications of structure; and that subsequent impressions bring the modified structure into action with all the functional efficiency dependent on prior modification of structure. These conclusions, as they hold of brain tissue in itself, and such tissue is homologous in the different orders of life, may be applied to animals. This involves a wider capacity in the cells and fibres belonging to brain structure. As to the interpretation of this admission, the most important requirement is, to observe the need for returning on the sensory apparatus, in order to ascertain what the facts really imply. There is before us a statement applicable to brain tissue as a whole. For more detailed interpretation, it is to be remarked that modification of brain structure must appear as a distinct occurrence connected with the action of each one of the special senses. This holds good in the history of each brain, and for each animal according to the conditions of its life; for the ant in its use of touch, for the chick in its use of sight, for the dog in its use of smell; and for each one of these animals in their use of other special senses. It seems, therefore, impossible to suggest that this facility, with which memory is connected, belongs to a separate division or lobe of the brain, in which the function could be localised. It is rather a general characteristic of brain tissue; the phase of memory involved belongs to each part of the brain, and is essentially involved in its ordinary functional activity. Hartley, therefore, correctly anticipated recent physiological research, when he said that "the rudiments of memory are laid in the perpetual recurrency of the same impressions, and clusters of impressions" (*On Man*, i. p. 374). In this, therefore, lies the explanation of the recognised familiarity of all animals with the tactile impressions, the sights, sounds, and smells continually recurring in their life; and also of the startled appearance of animals when arrested by an impression altogether strange.

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[1] *Science and Culture*, p. 211.

[2] *Ibid.* p. 213.

At this point we reach the limit of ascertained fact as to the functions of such a brain as the dog's. Ample physiological explanation we have of the complexity of the convoluted brain, acting as the governing organ of a complicated nerve system, and clear evidence of the dependence of this brain on sensory apparatus for full exercise of functional activity. The larger part of the commonly recognised actions of the dog, including those usually attributed to intelligence, are embraced within the explanations now given, and these are shown to be forms of sensori-motor activity. Whether all phases of the dog's intelligence are thus included, there may be reasonable grounds for doubt; but, at the very least, it must be allowed that all the ordinary features of the dog's life, apart from human intervention for its guidance, are embraced. The alternative seems to be, either that the dog's intelligence is accounted for by sensori-motor action, that is to say, that what we name intelligence is sensory action in the brain, in response to action of the sensory nerves; or, there is in this animal some higher phase of intelligence still to be explained, and superior to that attributed to the otter, pig, and ox. Probabilities are against the latter alternative, on the ground of continuity in the evolution of brain up the whole range of animal life, and the homologous functions of brain wherever found, varying only in accordance with complexity of structure. Such considerations, however, are not conclusive, though they are sufficient to involve a demand for careful scrutiny of available evidence.

For further analysis of the evidence at command, it is needful to pass now to the effects of imitation and training in the life of the dog. Capacity for imitation being essential for training, these two cannot well be separated; and with the conjunction, we may include training of young dogs by their mother, and training by man. The whelp, with hereditary aptitudes, acts as its mother does, and is checked and encouraged by her. Natural training applies in this case, as with other animals according to their species, mainly for unfolding the characteristic tendencies of the animal. Little light is here thrown upon range of intelligence. Opening sensibility, spontaneous activity, distinctiveness of temperament as more or less spirited, sum up nearly the whole results from observation of a litter of puppies. Everything of chief value for the present purpose is, therefore, obtained by concentration upon the results of human training.

There can be no doubt that the intelligence manifested by the dog is largely dependent on the constancy and closeness of its companionship with man. On the other hand, there is in the dog an inherent aptness for such companionship, giving it precedence in this respect over other animals. It is essential, therefore, to distinguish exactly the intelligence of the animal in guiding its own actions, from the intelligence apparent in following directions. The maxim is beyond dispute, that in order to profit by intelligent training, intelligence is required. The measure of intelligence in the animal, taken along with its bodily conformation, is, indeed, the measure of the possibilities of training. On the other hand, the maxim is no less certain, that imitated action does not in itself afford strong evidence of intelligence. It may even illustrate want of intellect in an animal, as mechanical contrivance does in performing the part of voluntary labour. On this account many of the tricks taught to dogs must be discounted as of comparatively little value here. Their cleverness is surprising in a dog, but this admission does not support a claim to high intelligence, the facts showing rather that the animal is made the plaything and sport of its owner.

If an approach to scientific accuracy is to be made, we must reach definite conceptions as to the possible range of training by clearly marking off its limits. The sensory apparatus, which has been made the test throughout, will be found to guide us here also. There are two perfectly distinct avenues of knowledge, in connection with which no attempt is made to train a dog; in the one case, because of the animal's superiority to us;

in the other, on account of deficiency in the structure of the sensory organ. These are Smell and Touch. No one dreams of training a dog to greater sensibility in the olfactory apparatus. So far as exercise of smell is concerned, the animal is the guide of man. For precisely the opposite reason, no one anticipates large results in the case of a dog, by its use of the discriminating power of touch. Accordingly, evidence in behalf of the dog coming from these two avenues of knowledge is almost a blank. This fact at once clears away a considerable amount of the confusion in which the evidence is at present involved. Further, it implies a great deal as to the structure of the argument as a whole, for the animal is pre-eminent in the sense least associated with intelligence in us, and defective in the sense on which we are largely and essentially dependent. Both positive and negative forms of evidence are here against the claim to high intelligence.

The organs in a dog available for his training are Sight and Hearing. Of these, the latter is reduced to a place of subordination, making it only slightly helpful. The range of possible achievement is further limited by the fact, that while we can communicate with the dog, it can communicate with us only in most restricted and hampered forms. Communication mainly from one side, must result in meagre training for the subordinate life. From lack of speech, the animal is greatly restricted as to what Mr. Darwin has somewhat questionably, yet happily too, described as "the expression of the Emotions." This term involves serious ambiguity, inasmuch as emotion includes many of the higher forms of feeling belonging to human life, in which animals have no share. Its use must therefore expose us to the risks arising from covert assumption of what is to be proved. On the other hand, Emotion stands psychologically in contrast with Thought, and in this respect points clearly to the fact that the expression of the dog is more an index to feeling or "Emotion" than to anything higher. In this relation, Mr. Darwin deals more with forms of expression than with analysis of Emotions. Yet to distinguish the quality of feeling in "Emotion" is essential. For example, taking *rage* as a test, man and animal may be allowed to be in close affinity, rage being in man fitly described either as "a short madness," or as animal passion. But there is a *grief* of which the animal can know nothing, and a *joy* to which it is an absolute stranger. Hence the importance of the question, What forms of Emotion admit of animal expression? In its answer, we shall readily recognise how limited is the range of expression belonging to the dog, while we allow that what is expressed is so vivid as to leave little room for uncertainty. A regard to these limits is essential for marking out the boundaries within which training may be reasonably attempted.

Along with sight and hearing, and in absence of power of speech, the avenues of influence are the animal's fondness or attachment for one who shows kindness, and its sensibility to pain; the one affording a method of encouraging effort, the other a means of deterring from action. To assign a first place to these, is to allow that there is deficiency in higher power. By such means we are enticing or threatening, but only in a very subordinate sense instructing, while we are most effectually training. These appliances place before us a completely subject nature,—subject to a degree impossible in case of an exercise of intelligence bearing any likeness to that of man.

We have now reached a standpoint from which we are able to contemplate steadily and clearly the evidence supplied by the most successful training of the dog. Much more can be made of it than of any other animal. Its dependence on man has become great,—its fondness for its master is so powerful as largely to affect its enjoyment of life,—its fears are easily stirred and readily become dominant,—its sensibility to pain is acute, and has been freely acted upon,—its companionship with man is so close as to have made it sensitive to every change of feeling appearing in its master's treatment of it, so that neglect becomes punishment. Bare enumeration of these characteristics leads us to recognise the aptness of Mr. Darwin's phrase,—"The Expression of the *Emotions*." At the same time, in harmony with the fundamental positions of neurology, all these characteristics can be assigned to the sensori-motor system. All these being granted, it seems possible to account for the facts illustrative of the intelligence of the dog; and if this be so, there is a wide difference between the intelligence which directs, and the intelligence which is directed. What was said as to the dog when the features of its brain were described, from p. 137 onwards, is in course of being explained; and we are here dealing with an animal highly intelligent, I incline to think, highest in intelligence, unless we make exception in favour of the ant, on account of its superiority in the sense of touch.

Evidence of the dog's intelligence as supplied by the results of human training, may be included under two divisions. Invariably the training has been concerned with regulation of the animal's activity, and we shall have a good view of the results if they are classified under restraints and inducements, showing how the animal has been checked and governed, and how far he has been led on to forms of activity to which there is no spontaneous proclivity.

1. Intelligent *restraint* as it appears in the conduct of the dog. A large body of evidence may be included under this head. I take, as a first example, restraint for an intelligible purpose exercised over a natural tendency, such as barking. An incident, reported in *Nature* (xxi. p. 324), will supply an illustration, and it is here given in the words of the narrator.

"I kept in town a bitch and three of its puppies; the former had a strong pair of lungs, and a weakness for letting the passers-by know it; when the latter became of age they exhibited all the hereditary peculiarities of the mother, and when the four animals joined in chorus, which was their favourite amusement at night, the result was anything but agreeable." Complaint being made, the owner had to train them to silence, the process being thus described:—"Having provided myself with a stick, I waited till I heard one of them bark, and I immediately went out and chastised him, or rather the one I thought had made the noise. I was, however, soon met by a difficulty; although I could recognise the bark of the old one, I could not discriminate well between those of the puppies; and whilst the old one was silenced after a few chastisements, the puppies were not; probably in mistake I had thrashed the wrong puppy. I therefore hit upon the plan of making the whole four responsible for each other, and as soon as I heard any one of them bark, I applied my stick freely to the whole four, the one after the other. When this had been done two or three times, I heard one of the puppies bark, and the next moment it gave a pitiful squeal; the mother had it by the neck. I went out and patted her, thus explaining that she had done well. She wagged her tail, as much as to say she understood me perfectly, and the dogs never barked again except on the most provoking occasions." This is a good example as to restraint of natural tendency, but it carries strong evidence of poverty of intellect in the dog. It was good and effective training for a group of dogs; it would have been poor and hurtful training for a group of children; indeed, would never be thought of in their case, except on the ground of voluntary participation in wrong-doing. The intellectual process of the trainer would have been different in the two cases, a fact implying that the dogs could not understand purposive silence, but in lieu of it needed to have a sensory association established between barking and punishment following. The same association could be induced in the case of a child, in exactly the same way, and with precisely the same result; but it could more readily and naturally be secured in another way, marking all the difference between government by sensibility and by intelligence. From the whole class of cases to which this one belongs, it seems a warrantable induction that for restraint of a natural disposition in case of the animal, reliance must be placed on associated sensibilities; in the case of the child, on such associations, and on understanding as well, the latter being so decidedly regulative that the former must be subordinated to it. The effect of the narrative is pictorially heightened by the skilful addition that when the mother was patted, "she wagged her tail, as much as to say she understood me perfectly well." But, in reality, she did not understand, and did not mean to suggest as much, for she knew only that if she checked her puppies she would be patted; if she did not, she and they would be thrashed. For what end they were being silenced, she did not know; and whether their treatment had been reasonable, she did not venture to say; for no one suggests that when a dog wags his tail as he looks on, we may conclude that he quite understands our conduct; but that her master wanted her and her puppies to cease their barking, she did know.

With pain and fear is next associated *grief*, the sense of which is deep in the dog. A good illustration is recorded by Mr. Romanes, as supplied by a correspondent. It concerns a Skye terrier, which had a strong aversion to being washed. The writer, Mrs. E. Picton, gives the narrative in the following form:—"In process of time this aversion increased so much that all the servants I had refused to perform the ablutions, being in terror of doing so, from the ferocity the animal evinced on such occasions. I myself did not undertake the office, for though the animal was passionately attached to me, such was his horror of the operation, that even I was not safe. Threats, beating, and starving were all of no avail; he still persisted in his obstinacy. At length I hit upon a new device. Leaving him perfectly free, and not curtailing his liberty in any way, I let him know by taking no notice of him, that he had offended me. When I returned home, I took no notice of his demonstrative welcome, and when he came looking up at me for caresses, when I was engaged either in reading or needlework, I deliberately turned my head aside. This state of things continued for about a week or ten days, and the poor animal looked wretched and forlorn. There was evidently a conflict going on within him, which told visibly on his outward appearance. At length one morning he crept quickly up to me, and gave me a look which said as plainly as any spoken words could have done, 'I can stand it no longer; I submit.' And submit he did quite quietly and patiently to one of the roughest ablutions it had ever been his lot to experience; for by this time he sorely needed it. After it was over, he bounded to me with a joyous bark, and wag of his tail, saying unmistakeably, 'I know all is right now.' When the period for the next ablution came round, the old spirit of obstinacy resumed its sway for a while, but a single look at my averted countenance was sufficient for him, and he again submitted without a murmur. Must there not have been something akin to the reasoning faculty in the breast of an animal who could thus for ten days carry on such a struggle?"[1] To go directly to the answer of the closing query might be unwise; preliminary analysis may help towards the fuller reply we are seeking.

[1] Romanes's *Animal Intelligence*, p. 440.

Aversion to discomfort is no speciality of intelligent animals, but a common characteristic of all sentient beings. It is, indeed, a primary feature of sentiency in the lowest degree, as has appeared in the case of the Ascidian, p. 203. Again, uneasiness under a sense of displeasure is one of the most familiar forms of sensory impression in the life of the dog; and displeasure on the human countenance is expressed, as Mr. Darwin remarks, in a manner analogous to the frown on a dog's face. Besides, sensitiveness often leads to mistaken trouble, on account of misunderstanding of what is meant. Further, persistence and force in unreasoning aversions, what we naturally call "obstinacy," present a phase of animal sentiency quite inbred, and independent of all training. Indeed, as this case illustrates, the perplexities and difficulties of animal training are encountered chiefly through determined conflict with such animal tendencies. It is true that we have a considerable amount of similar experience in training our children, for they have a share in animal propensities, and in their case training is the aid a larger experience affords them in their effort to bring animal impulses and restraints under government of reason. The similarity and the contrast in the two cases may direct towards a trustworthy conclusion here. In a child's life, conflict between fear of suffering and grief under displeasure, maintained with great obstinacy, is so far from being regarded as a manifestation of reasoning power, that it is held to illustrate the contrary, so that the close of the conflict is commonly and fitly described, as resulting from this, that the child has been "brought to reason." On these grounds, we must conclude that the apparent testimony for "something akin to the reasoning faculty in the breast of an animal," is insufficient, while an illustration is afforded of the readiness with which we attribute our own forms of mental exercise to the animals we cherish and control.

Under this division of evidence must be included all cases of restraint on thieving tendencies, by fear of punishment; and the whole series of illustrations of what has been named "conscience" in a dog. From the latter class of cases, the theory of evolution of "mental habits and actions" appears to find support. But the evidence is not convincing. Its deficiency appears in these prominent features, that the references are constantly to an experience of displeasure, for they are uniformly connected with imposed restraints; the conduct of the dog pointed to is a manifestation of fear or grief, on account of punishment either apprehended or endured; and we interpret the animal's feeling by a supposed analogy with remorse. What appears is an expression of *Emotion* or troubled feeling, but there is no evidence of positive recognition of truth, or of intelligible law, essential to an exercise of conscience. In precisely the same way, our reasonings are largely at fault when we attribute to *conscience* in a savage, what is the product of unreasoning superstition or blind tradition. What appears in the dog is nothing more than the persisting brain effects of long familiarity with his master's displeasure for doing certain things, and his dread of that when the deed is done. One of the clearest and most forcible proofs of this is found in the multitude of cases in which the dog looks "self-convicted," "self-condemned," ashamed, and troubled, when he has failed to please his master, without any fault on his own part. A single illustration will suffice. A gentleman had trained his dog to go after dinner up-stairs to his bedroom to fetch his tobacco pouch from a peg on which it hung. On one occasion, after an absence from home, he sent his dog on the usual errand; but he returned without the pouch, crouching, his tail between his legs, and all the evidence of troubled emotion belonging to a self-condemned culprit. His master stormed, threatened, and sent him back again. Once more the dog went, but again returned as before, looking wretched, and crouching on the ground as if punishment were inevitable. His master got up in anger, reproached him for his conduct, and ordered him off again on pain of a scourging. The dog went up-stairs once more; in a short time his master heard an extraordinary noise on the stair; and, going to ascertain the cause, he found the dog laboriously dragging his portmanteau down-stairs. The tobacco pouch was not on its peg; but, guided by smell, the dog recognised its habitat, and did the best he could to meet the demand of a master who had unwittingly become unreasonable, whose blunder a dog could not expose, but to whose anger a dog must submit. Here we seem to have all the signs of a genuine "remorse;" but in reality we find evidence of our own mistake in application of the word. Nevertheless the grief of a dog for having done what his master condemns is real, and quite touching to witness. This impresses our imagination, and inclines us to attribute *conscience* to the dog. Accordingly we find Mr. Darwin say, "I agree with Agassiz that dogs possess something very like a conscience" (*Descent of Man*, 2d ed. p. 103). But when Mr. Darwin shortly afterwards comes to discuss the characteristics of a moral being, his sagacity and analytic power are too strong to support the admission. He says, "A moral being is one who is capable of comparing his past and future actions or motives, and of approving or disapproving of them. We have no reason to suppose that any of the lower animals have this capacity; therefore, when a Newfoundland dog drags a child out of the water, or a monkey faces danger to rescue its comrade, or takes charge of an orphan monkey, we do not call its conduct moral" (*Ib.* p. 111).

We pass next to consider the effects of training when there is *inducement to act.* In all phases of training which aim at a distinct acquisition on the dog's part, reliance is placed mainly on the animal's susceptibility to kindness, and its power of imitation. It must see the action often done, must be led to attempt it, must associate with its own efforts its master's approval, must have great patience exercised towards it, and it may have to endure much suffering. In these, we have the key to a great number of recorded acquirements. For illustration, reference may be made to the stationmaster's dog at Hawkesbury station, between Nuneaton and Coventry (*Nature*, xx. p. 243), which "would listen with marvellous patience and acuteness for the signal intimating that a train was approaching the station, and then, almost with the speed of lightning, rush to the signal-box, and seizing the bell between its teeth, shake it heartily, and thus apprise the waiting passengers of its approach." This animal spent its life among the associations of the railway station, where all things are arranged by mechanical contrivances, and in a fixed order. The stationmaster making use of his intervals of quiet, set himself to establish the associations in the brain of his dog, and the experiment proved that the association was possible, and that the dog's jaws could in some measure make up for want of a hand. The result was as interesting on account of the muscular effort of "seizing the bell between its teeth, and shaking it heartily," as on account of the imitative power manifested. The achievement hardly proves, however, that "the fox-terrier, known as Pincher, was an animal possessing almost human intelligence;" but it well illustrates how readily we fall in with such a mode of interpretation as the analogy of our own intelligence affords. The feat depended on the established association of sensory impressions which led to the action. And such association is readily within the compass of organism. Thus a parrot so distinguishes the closing of the front door, and the voice of his master, as to whistle a recognised tune by way of welcome; and on sudden opening of the back door, the same parrot instantly calls "George," the name of the coachman, who is commonly called there. Association of sensory centres, disposing them to act together, as indicated in page 230, with co-ordination of motor centres leading on to muscular action, seem to include all the facts.

Training in pointing, setting, and retrieving, is directed obviously on the natural instinct of the dog, and calls into action the sense of smell, in which he is pre-eminent. Accordingly the results of such training give less occasion for remark, in part because sensory apparatus is conspicuously active; in part because the results of training appear in a permanent condition of the organism. When individuals of the same race of dogs are compared, and directions from dog-trainers as to selection are considered, it is a significant fact that chief importance is assigned to the comparative spirit or boldness of the dog. Thus a shy dog is rejected, and in many cases is shot, as unlikely to repay the labour of training. Extracts from books of practical directions for the rearing of dogs will afford the best testimony here. "I would not only never breed from a shy dog, but I would never have one. It shows itself generally at four weeks old, and by stamping on the floor, or a sudden rap against the pannel of the kennel, it may at once be detected. The shy whelp will put his tail between his legs and cower; the bold ones will merely prick their ears and show curiosity."[1] A strong olfactory organ, with good sight and hearing, found in all dogs, and a brisk spirited disposition, found only in some, supply the requisites for hopeful training. The hereditary results of training appear in our different races of dogs, such as the pointer or retriever, for, as Mr. Darwin remarks, "a young pointer, when it first scents game, apparently cannot help pointing."[2] Many actions are thus explained, which at first sight we naturally assign to intelligence. Take, for example, the case described by Dr. Wilson (Romanes's *Animal Intelligence*, p. 461), "There is a shrubbery near the house, about 200 or 300 yards long, and running in the shape of a horse-shoe. A small terrier used to start a rabbit nearly every morning, at the end of the shrubbery next the house, and hunt him through the whole length of it to the other end, where the rabbit escaped into an old drain. The dog then appears to have come to the conclusion that the chord of a circle is shorter than its arc, for he raised the rabbit again, and instead of following him through the shrubbery as usual, he took the short cut to the drain, and was ready and in waiting on the rabbit when he arrived, and caught him." An attempt to apply generally the principle of interpretation suggested here would show how unsuitable it is. Take a hare starting from the course when pursued by the hound; or a terrier rising on his hind legs, and turning as on a pivot when in pursuit of a bee or a sparrow. Does the hare act as she does because of having ascertained the difference between an angle and a curve; or does the terrier resort to his method of pursuit because of having gained some acquaintance with the properties of a circle? It is clearly impossible to interpret in this manner. The terrier in the shrubbery did only what the collie is doing habitually, in accordance with easily acquired associations.

The highest results of training are seen in the *Scotch Collie*, which by almost common consent is allowed to be the most intelligent of dogs. Stonehenge says, "The sagacity and perseverance of this dog are wonderful, and the instances in which he has succeeded in saving sheep and lambs under perilous circumstances are beyond all description" (*The Dog in Health and Disease*, p. 120). "Idstone," already quoted, allows decidedly the precedence to the Scotch collie over the English sheep-dog, and gives as the chief explanation the general superiority of the Scotch shepherd over the English.[1] Such superiority in the shepherd of the northern portion of our country may probably be admitted, for Scotland is so much more a pastoral country, that the rearing of sheep, and training of sheep-dogs, has had the best efforts of a highly intelligent order of men. But considerable importance must be assigned to the character of the country in which the dogs are trained. The Scotch hill-sides and vast mountain ranges present fields for the training of dogs, in comparison with which the enclosed pasture grounds of the south are greatly inferior. The Scotch collie has to do more difficult work, and accordingly acquires more sagacity. It is an example of the maxim, that much must be endured in order that great things may be achieved. Undoubtedly, the sagacity of the Scotch collie is a marvel. In the history of dog life, there is nothing to compare with it. His training applies to a definite round of engagements, but this includes such variety of action, and calls so much for independent execution of his master's orders, that there is no finer example of the manner in which an animal can act on recognised signals. This illustration is the more impressive to our imagination, because sight and hearing are the senses chiefly utilised by his trainer, but it must be remembered that in the gathering of sheep from a hill-side, the sense of smell performs a large part quite unobserved by us, and is of the greatest value to the shepherd when the flock must be moved during the night. Referring to such a case, a shepherd explained his position in these words:—"I couldn't see the flock, but as I walked in front, I could hear 'Quick' bark now and then, and I warrant they were all right" (*The Dog*, by "Idstone," p. 225). This will indicate how much the sense of smell is doing in the collie's management of sheep. A relationship between the dog and the sheep becomes established, and a trainer of dogs marks it as a disadvantage to an animal, when his labours include "guardianship or conduct of cattle, as well as flocks."

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[1] *The Dog, with simple Directions for his Treatment, and Notices of the best Dogs of the day, and their Breeders or Exhibitors*, by "Idstone," p. 24.

[2] *Descent of Man*, 2d ed. p. 105

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[1] *The Dog*, p. 224.

(*Ib.* p. 221). How completely the guidance of sheep becomes an inherited instinct, analogous to that of the pointer in relation to game, is well illustrated by Dr. John Brown's story, in his chapter on "Our Dogs," of the small collie he had which regularly disappeared on the Tuesday evening, and returned quite exhausted on Wednesday evening. The explanation was discovered long after the practice had been established. Attracted by the flocks of sheep entering the city for the weekly market, she went regularly to the market-place to help all the shepherds in getting their sheep into the "buchts" or sheep-pens.[1]

In judging as to the intelligence of the "collie," it is needful first to mark off actions clearly attributable to inherited instinct, or to power of smell. To the former we must assign the inherent inclination to be occupied among sheep, as in the case described by Dr. John Brown; to the latter the apparently marvellous knowledge that there are sheep unseen still to be brought in, and the discovery of a lost sheep in a crevice, in mist, or in snow drift. Beyond these, the special marks of intelligence are found in the understanding of signs, and cries, and the apparent knowledge of the meaning of words. It must, however, be noticed that the dog performs without orders the same acts that he does when commanded. Considerable advantage to this breed of dogs has resulted from the fact that their training is not merely for a portion of early life, or part of the year, but is life-long in companionship with a man who constantly values their help. "Much of the collie's sense results from his constant intercourse with his master, and his being taught, praised, blamed, in fact, educated by one man. He resents any change of ownership, and he very frequently refuses to work for his new proprietor on any terms."[2] It is in keeping with this, that we find in his conduct the best examples of what animal intelligence has accomplished. His understanding of what his master says, is so clear and prompt that he has been known to act instantly on the utterance of familiar words, repeated quietly in the midst of general conversation, when the dog lay quietly by, as if asleep.[1] Nowhere so much as here do we find evidence to favour the hypothesis that some of the higher animals possess a lower order of "mind." But analysis greatly reduces the available evidence. No higher or more impressive testimony has been given than that last referred to, interpreting language designedly mixed up with general conversation. But, wonderful as the case is, it affords strong evidence as to the restricted intelligence of the dog. The words understood by the animal were, in the relation in which they were uttered, really unintelligible to the persons listening to the conversation. "The cow is in the potatoes," was the phrase interjected in quite unmeaning connections, in order to test the dog, on utterance of which he rushed out. The test was, therefore, one as to the extent of the dog's familiarity with this phrase, or the vividness of the impression it had made on the brain, and on the motor apparatus co-ordinated with the centre of sensibility. Besides, "potatoes" is a very readily distinguishable sound, easily recognised; just as a waiter will catch *pommes de terre*, or *Kartoffeln*, when he knows hardly anything else in the language to which the words belong. What is a very striking proof of unexpected intelligence, at the same time affords testimony to the exceedingly restricted intelligence involved. The dog recognised the more clearly and certainly the phrase "The cow is in the potatoes," just because everything else in the conversation made no impression upon his ear. This case must, therefore, be taken with other cases in which animals interpret the words of their guide. In this respect the horse affords quite as clear testimony as the collie does; for, while carriage horses, constantly guided by the rein alone, supply little evidence in this form, horses working in carts, or at agricultural work, are accustomed to move to right or left according to the call of their driver; and the recognised calls are so thoroughly known and obeyed, that even in the crowded streets of our large cities, drivers trust implicitly to this mode of guidance. The ox, when trained to work in harness, and specially to do its share of work in a wagon team, shows the same capacity. The case of the dog is apt to impress us more because of the practice of using ordinary vocables, instead of sounds or cries traditionally appropriated for guidance of animals. But there does not seem to be established in behalf of the dog any claim to a real understanding of language.

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[1] *Horæ Subsecivæ*, vol. i. p. 194. A shepherd's account of Wylie, "the wee fell yin," is a delightful bit of broad Scotch. He said, "She's a perfect meeracle; flees about like a speerit, and never gangs wrang; wears but never grups, and beats a' oor dowgs."

[2] *The Dog*, by "Idstone," p. 220.

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[1] *The Dog*, by "Idstone," p. 218.

To complete this survey, it is needful to place in clear relief the evidence of poverty of intellect, without which attention is concentrated on only one division of the evidence. For this, there is the more need on account of the constant risk of identifying sensori-motor activity with intelligence. Reference has already been made to the stupidity of the dog when his reliance is placed solely on vision, the highest of the special senses. In exercise of smell, he is never at fault; in exercise of sight, he shows greatly inferior capacity. This in itself is strong evidence of the lack of intelligent power. If a stick is raised to point to an object, he is only perplexed; a person lifting a weight from the ground will make him shrink, as if harm were intended; he will stand barking at a tassel dangling on the end of a rod, will approach it guardedly, and then, smelling it, pass on as if it were nothing. If intelligence, I do not say of the degree, but of the *kind*, belonging to man were in possession of the dog, it would make much larger use of the sense of sight. The limited range of its own acquirements, even when placed in the most advantageous circumstances, confirms this view. Left to himself, he makes slight progress. His skill appears mainly in catching prey, where smell makes up for lack of intelligence in use of sight. Even in the domesticated state, his imitative power finds exercise in nothing more than in matters affecting his food, or ingress and egress from our rooms. In respect of the last he has no precedence, for both horses and oxen are known to open the gate of the field or court in which they are kept. If events do not affect his own appetite, comfort, or habitual occupations, the dog's observations are of no value, however frequently the events recur. The conclusion thus indicated is confirmed by the recognised limits of his training. We do not attempt to train the ant; any such interference would be a hindrance not a help. We do attempt to train the dog, more than the horse or the ox, because the dog can be more an attendant, and can render service for which the other two are unsuited. But our highest efforts are directed towards training the dog for a certain round of actions suited to his physical aptitudes. We do not set ourselves to *instruct* him; we do not dream of attempting to communicate knowledge simply as knowledge, that is, for its own sake. Our high admiration of the dog rests on the wonders he can accomplish, short of possession and exercise of intelligence to which instruction is a necessity and delight.

In strict accordance with the conclusions now reached, are these two facts:—popular admiration of the dog, and popular acknowledgment of the low intellectual level of the animal as shown in many of its actions. Of the former, ample indication has been given; of the latter, our literature supplies full illustration. Thus Shakespeare makes Brutus condemn the conduct of Cassius:

> "I had rather be a dog, and bay the moon,
> Than such a Roman;"

an allusion in which the admiration of the dog, and the contempt for it, are skilfully blended. And so in *King Lear*, the fool, when his warnings are resented, is made to say:

> "Truth's a dog that must to kennel."

Some perplexity must be admitted as still hanging over the comparative intelligence of the Ant and Dog. As already said, this perplexity arises from the diversity of organ in use by the two animals, and the consequent impossibility of instituting exact comparisons. This consideration strongly confirms a theory which attributes a prominent place to special sensory apparatus as accounting for marked intelligence. The ant has superiority in this respect, that it is entirely independent of training, whereas training has raised the dog to his present position. On the other hand, the dog has been trained to an exercise of intelligence which the ant cannot reach.

That the dog's manifestation of intelligence is marvellous, is universally admitted; and equally that this eminence is due to the closeness of companionship with man, and persistent training, through a long series of generations, of different breeds of dogs. Mr. Romanes has admirably indicated in the following sentences, the singular value of the dog's history as illustrating animal intelligence. "The whole psychological character of the dog may be said to have been moulded by human agency with reference to human requirements, so that now it is not more true that man has in a sense created the structure of the bulldog and greyhound, than that he has implanted the instincts of the watch-dog and pointer. The definite proof which we thus have afforded of the transforming and creating influence exerted upon the mental character and instincts of species by long and persistent training, coupled with artificial selection, furnishes the strongest possible corroboration of the theory which assigns psychological development in general to the joint operation of individual experience coupled with natural selection. For thousands of years man has here been virtually, though unconsciously, performing what evolutionists may regard as a gigantic experiment upon the potency of individual experience accumulated by heredity; and now there stands before us this most wonderful monument of his labours—the culmination of his experiment in the transformed psychology of the dog."[1]

Reserving, for reasons immediately to appear, the merits of an argument from "artificial selection" to "natural selection;" and allowing for possible ambiguities under the phrase "psychological development in general;" the grand facts concerning the intelligence of the dog, and the history of its development, are strikingly presented by Mr. Romanes, and their statement will command general assent. These facts must, indeed, be allowed a large determining influence over our conceptions concerning the natural capacity and possible attainments of animals. Even allowing, as we must, for thousands of years, as needful to account for the development of separate races of dogs, and for the degree of intelligence shown by the watch-dog, and pointer, and collie, the results, studied with all the aids which physiology, specially in the department of neurology, now supplies, are marvellous.

These acknowledgments, however, lead on to conclusions in advance of those which have hitherto gained attention; conclusions which need to have their place and value recognised as bearing on the whole range of investigation concerning the problems of biology.

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[1] *Animal Intelligence*, p. 437.

In demonstrating that the high intelligence of the dog is the product of thousands of years of human training, it is demonstrated that the argument from the intelligence of the dog in support of evolution of existence by natural selection, through the struggle for existence, must be abandoned, and the whole theory of evolution modified accordingly. By universal consent the intelligence of the dog is a distinct product of thousands of years of human training, so that man has virtually created the dog of the present time. The history of this animal is, therefore, as Mr. Romanes reasonably affirms, "a gigantic experiment upon the potency of individual experience accumulated by heredity." But, this granted, the dog is thereby of necessity lifted out of the order of events illustrating evolution by natural selection; and the blank thus occasioned is sufficiently marked to arrest attention. Man has interposed, and has interfered with the course of nature. The fact of evolution is not in any way discredited by this interposition; on the contrary, it is so far clearly demonstrated, and it is illustrated in a manner impressive to our imagination, and helpful to scientific thought. These positions have been clearly and convincingly argued by Mr. Darwin in his sections on "Selection by Man," and "Unconscious Selection" (*Origin of Species*, 6th ed. pp. 22-29). As he has clearly stated, "one of the most remarkable features in our domesticated races is that we see in them adaptation, not to the animal's or plant's own good, but to man's use, or fancy" (p. 22). And again, "Man selects only for his own good; Nature only for that of the being which she tends" (p. 65). Let us apply these data to the facts now under review. For this, a distinction must be drawn between evolution of animal existence, and the evolution of animal intelligence, while we recognise that the conditions of life and the conditions of intelligence must act and react upon each other. For the purpose now in view, as it immediately concerns intelligence, the two phases must be carefully distinguished. The place of the dog in the line of animal existence remains as in the order of nature, affected only by modifications inevitably occurring under training. But, it is granted, as Mr. Romanes expresses it, that "the whole psychological character of the dog may be said to have been moulded by human agency with reference to human requirements." Accordingly, the intelligence of the dog is withdrawn from available evidence as to natural evolution of intelligence in the world. On this account, an argument from the intelligence of the dog (the most intelligent of the higher animals) to the evolution of human intelligence, is shown to be logically impossible. There is no process from the lower to the higher, for the intelligence of man is the essential requisite by which to account for the eminence of the dog. Here in the history of events, the action of intelligence has not been from below upwards, but from above downwards.

And how careful and constant must be the application of a higher intelligence in order that the utmost advantage may be taken of possible variation in the subordinate life, will appear from Mr. Darwin's remark: "Not one man in a thousand has accuracy of eye and judgment sufficient to become an eminent breeder" (p. 23).

What is here indicated as a necessary modification of a theory of evolution of animate existence, does not imply a denial of a law of evolution as operating within living organism; on the contrary, it rests upon the action of such a law as essential; but it materially affects the structure of the theory of evolution by natural selection taken as a whole, that is, as a theory of cosmic existence. Scientific thought and imagination have been dominated by the conception of "continuity" to an extent which accumulating evidence refuses to sustain. This conception has rendered important service to science in the opposition it has offered to an admission of sudden breaks, or sudden advances by leaps and bounds, assumed to be independent of previously existing conditions. But, along with this, it has considerably averted the attention of competent observers from the complexity of the cosmic problem. This fact becomes most apparent in relation to our theory of intelligence in the world, and it is directly illustrated by the readiness with which the intelligence of the dog is regarded as furnishing "the strongest possible corroboration of the theory which assigns psychological development in general to the joint operation of individual experience coupled with natural selection." In reality, the intelligence of the dog falls to be abstracted from available evidence, inasmuch as it is the product of thousands of years of human training.

The bearing of this consideration, on the evolution theory, as a cosmic theory, and specially as claiming to include the grand psychological problem, is in the highest degree important. The conception of "continuity" has favoured a representation which makes human intelligence the ultimatum of a continuous line of progress,—a product of evolution from lower intelligence. The effect of this fallacy has been to encourage exalted estimates of animal intelligence, along with reduced estimates of human intellect; to discredit the reference to "mind," "soul," or "spirit," as a distinct order of existence; and to reduce all things to mechanical order. This representation is at variance with recognised facts, and is largely attributable to the fallacy here exposed. Taking the intelligence of the dog, which is so marked that it is difficult to present any of the higher animals to compare with it, this intelligence is explained, not by natural evolution, but by the persistent application of human sagacity and skill. No representation of cosmic order is consistent with facts which does not include the "mind" of man as an essential prerequisite for evolution of the dog's intelligence;—the superior intellect being necessary to bring the lower life up to its present level, making it capable of a measure of companionship with man, and fit for rendering a degree of service, without which so large a share of attention would never have been given to the animal.

From the dog, we turn to the MONKEY and APE, which are best taken together on account of their affinity, and which both resemble the bodily configuration of man as no other animals do. The comparative structure of the brains of these two animals has already been described (pp. 149-174), and along with this the leading points of resemblance and contrast when their brain is compared with the human brain. Proceeding upon these data, we have now to consider more definitely the comparative intelligence of these animals; and to connect with this, express reference to the comparative development of sensory apparatus. In making the transition from the dog, the first marked characteristic is the enormous reduction in relative importance of the olfactory apparatus. The protruding bulb of smell disappears, being withdrawn to a position considerably within the margin of the base of the brain, for both bulb and tract are greatly diminished. This difference applies in both cases. Both animals are, however, quick in sight and hearing, being quickened under the conditions of their life in the silent forest, and among the close twining branches. In the sense of touch neither animal is specially distinguished. The monkey is more sensitive in the general nerve system, and has a hand serviceable for discrimination. The hand of the Ape seems analogous, but is spoken of by Du Chaillu as "callous" (p. 165), while the general nerve system is the reverse of sensitive (p. 169). The one speciality among the sensory organs of the ape, is the sensibility of the under lip, which is capable of being stretched out to a singular extent. The power of protrusion belonging to this organ is strikingly represented in Darwin's *Expression of the Emotions*, fig. 18, p. 141, a figure drawn from life by Mr. Wood. Mr. Darwin says (p. 140), "the lips of young orangs and chimpanzees are protruded, sometimes to a wonderful degree, under various circumstances. They act thus not only when slightly angered, sulky, or disappointed, but when alarmed at anything, and likewise when pleased." There is much that is suggestive in this, as connected with comparative sensory appliances in animal life; but evidence drawn from the life of the animal in its ordinary haunts is difficult to find. Sensitiveness in the under lip is seated in an organ which can be only slightly utilised; and yet in view of the conditions of life, it could not become a characteristic without functional use. Mere "expression of the emotions" will not readily explain the feature. Judging from analogy in the case of the horse, which uses the under lip for prehensile purposes, and from the ape's mode of life as a fruit eater, it seems more probable that the sensibility of the under lip is connected with the ape's search for fruit. This would give a natural interpretation, and would involve a ready application of sensory apparatus as a discriminating instrument; but it would not imply anything important as testimony for intelligence.

The comparative brain development of both monkey and ape having been already described in all needful detail, we have only here to keep before us a general statement such as that given on p. 174. The monkey's brain has convolutions in outline, and only slight development of the frontal and occipital regions, "a sort of skeleton map of man's," as shown in fig. 35, p. 150. The brain of the ape is much more filled up in detail of convolution, and though also short of the development of man's brain in the frontal and occipital regions, it is more full than that of the monkey, being very nearly an exact miniature of the human brain, as shown in Professor Huxley's extended drawing given above, fig. 37, p. 154. This will be still more readily recognised by the figure of the brain of the orang, here introduced, from Dr. Rolleston's memoir on that animal, where it is carefully compared with the human brain in every particular.[1]

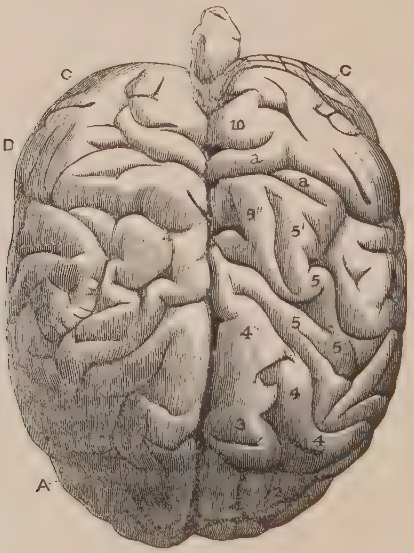

FIG. 46.—BRAIN OF THE ORANG—A young male, 2 feet 7 inches in height.

This brain is the nearest resemblance to man's known to exist in the animal kingdom. The main points of inferiority are the following: the smaller size of the organ, relatively to the bulk of body; inferior development of the frontal and occipital regions; and the diminished size of the corpus callosum, which is shorter and thinner, indicating a smaller degree of intercommunication between the hemispheres. The main points in which the ape shows superiority over man are these: the greater size of the nerve fibres, as shown in the greater thickness of the strand of nerve fibre issuing from the brain, which appears clearly in the figure here introduced; and the much greater muscular power of the animal.

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[1] *Nat. Hist. Rev.*, 1861, and collected edition of his writings, edited by Professor Turner.

The comparison of the monkey and ape aids greatly in the study of comparative intelligence, contributing an important test as to the true theory of interpretation. If brain structure in itself determines the measure of intelligence, the ape must undoubtedly hold the first place. If sensibility in sensory apparatus, even with comparative inferiority of brain structure, may give a higher power of discrimination, the intelligence of the monkey may surpass that of the ape. That the monkey is really the superior of the two in respect of intelligence seems clear. The monkey has greater power of touch, greater agility, greater sensitiveness over the entire body, and consequently is superior in observation and curiosity. The appearances of things, and changes in the conditions of its own life, mean much more for the monkey than for the ape. The smaller animal is structurally inferior in everything save sensibility of nerve organisation; but, on account of superiority in this single respect it is the superior in intelligence. The ape is sluggish, indifferent, and liable to be roused only when hungry or irritated. Its whole characteristics are thus unfavourable for development of intellectual power. Strong as the animal is, and capable of much service to man in so far as labour power is concerned, there is little encouragement to bestow pains on its training. On this single account, it seems certain, and Mr. Darwin expressly anticipates the result (*Descent of Man*, p. 156), that apes will disappear before advancing population, and the monkeys are likely to follow, unlesss their amusing tricks and more tameable disposition grant them respite for a season.

What is now required is careful statement of the comparative intelligence of the monkey, founded on evidence cautiously gathered, and exactly recorded. This has now been supplied by Mr. Romanes, who has at this point, as at many others, rendered special service to the study of comparative intelligence in animals.

Mr. Romanes has given the results of fully two months' carefully recorded observations of a monkey (Brown Capuchin —*Cebus fatuellus*, Linn.—Brazil), which he had from the collection of the Zoological Society of London. Mr. Romanes says, "I selected a specimen of *Cebus fatuellus*, which appeared to me the most intelligent monkey in the collection."[1] The author has been so deeply impressed by the results obtained, that he is prepared to take these observations as supplying ample materials from which to construct the critical part of the argument in support of psychological evolution. He says, "In my next work, I shall hope to show how, from so high a starting-point, the psychology of the monkey has passed into that of the man."[2] An analysis of this evidence will contribute materials for judgment.

First.—Disposition. The animal shows strong attachment to some persons, antipathy to others, great destructive tendency, extreme irritability, cunning, and much tenacity when his possessions are threatened.

Second.—Intelligence. He uses a hammer for breaking nuts, a stick or shovel for drawing a nut nearer; he watches against injury when he overturns a heavy body. When chained to a ring, he slipped the chain through and through in hope of loosening it, then hammered at the ring as if to break it, then pulled the chain through the ring, until he completely blocked it. He seeks an elevated position for hurling missiles at any one. He has learned to unscrew and rescrew handle of brush, and knobs on the fender; and he opens and closes the folding window-shutters. He has great power of imitation, and tries to unlock the trunk in which his nuts are kept.

Third.—Poverty of intellect. "He bit me in several places to-day. . . . I took no notice, but he seemed ashamed of himself afterwards, hiding his face in his arms and sitting quiet for a time." Subsequently,—"I find this quietness was not due to shame; . . . he always sits quiet and dull after a fit of passion, being, I think, fatigued." When his chain was fastened in a ring, "he began to investigate its new connection, and continued to do so *for hours*, passing the chain backward and forward through the ring." He tried with the key to unlock the trunk in which his nuts were kept, and when he failed, he began to feel with the key round the neighbourhood of the lock. "The explanation is this: my mother's sight being bad, she often misses the lock, and feels all round for it." The monkey imitates all this, "and though he could see perfectly well how to put the key in straight himself, he went through this useless operation first." "Sometimes, if the chain is entangled, . . . he sits quietly down beside me, and begins picking at the chain with his fingers as if to help me to untie it. I cannot say, however, that he succeeds in helping me at all." With such examples, we might agree with Mr. Romanes in speaking "of the tireless spirit of investigation," but it seems needful to add, "useless investigation." There is little here approaching to the systematic, self-originated, productive effort common in the history of the ant.

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[1] *Animal Intelligence*, p. 483.

[2] *Ib.* p. 498.

As to poverty of intellect in the monkey, similar testimony is borne by Mr. Frank Buckland, a highly competent and reliable witness. His statement is the following:—"Having lived with monkeys in my sitting-room for so many years, one thing I have learned for certain is that monkeys will not intelligently imitate the actions of men; their sense of hearing, smelling, and sight, far surpasses that of ordinary civilised human beings, but their brain is not sufficiently developed to imitate intelligently. For instance, a monkey will sit before a fire till it goes out, but the monkey will never put a bit of wood or coal on the fire to keep it alight. I have tried this over and over again with my monkey, The Old Hag, who was my constant companion at the fireside for so many years. I have placed a stick in her hand, and guided her hand towards the fire, but her brain could not see the connection between the burning stick and the warmth produced therefrom" (*Notes and Jottings from Animal Life*, p. 12). This is in strict harmony with the testimony of Andrew Battell as to Apes, quoted by Professor Huxley, and given above, p. 168.

It is true that the monkey and ape are observed chiefly in a captive state, where few facilities are afforded for the natural exercise of their powers, and for this allowance must be made On the other hand, they have all the advantages of domestication, with manifold facilities for the exercise of imitative power, in which monkeys are strong, while they have a structure-making imitation possible to a greater degree than in the case of any other animal. Yet, the results are not great, and even monkeys seem to make no advance giving promise of higher results. In companionship with man, and with even less imitative power, the dog far more fully understands man, recognising his purpose, and deliberately carrying it out. It has, however, taken thousands of years to bring the dog to his present position.

From these data, there seems warrant for these two inferences, that the monkey is superior to the ape in intelligence; and that both are greatly inferior to the dog. While, therefore, it continues warrantable to speak, as Professor Huxley did in 1863, of "the great gulf which intervenes between the lowest man and the highest ape" (*Man's Place*, p. 102), we must add, that this is a greater gulf than that which separates the monkey from man, and still greater than that which separates the dog from man. And, with these things, we must conclude that comparative intelligence in an animal is not determined by comparative brain structure alone; but by structure and sensibility of sensory apparatus, as supplying discriminative power supplementary to the functions which can be assigned to brain.

In the Elephant and the Whale, we recognise the relation of complicated brain structure, rich in beautiful convolutions, with large muscular development. This concerns the relation of mass and detailed structure of brain, to mass and motor activity in the governed organism. Here we have a more complicated brain, with no equivalent increase of intelligence, probably in the case of the whale, with less intelligence. We seem once more in a different circle of problems, involving the relation of mass and complication of structure of brain to muscular power, and to swiftness of movement. On the other hand, we have in the ape (see p. 173) much greater strength than in man, with a brain less in bulk, and less convoluted, than the human brain.

Anything more striking in detailed convolution of brain does not exist in animal life, than the brain of the elephant, p. 175; and the brain of the whale, p. 181. In the elephant the speciality in the sensory apparatus is connected with the trunk, at the extremity of which there is such sensibility as to imply an organ of touch capable of considerable delicacy of discrimination. The trunk can perform to some extent the functions at once of an arm, and of a touch organ. "It is a delicate and sensitive organ, and never used for rough work" (p. 178). In the case of the elephant we have all the advantages for observation connected with domestication, training, and work done in the service of man. Besides, the animal is distinguished for "obedience, gentleness, and patience" (p. 179). Nevertheless, on the testimony of Mr. Sanderson, based on observations extending over thirteen years, "it is in many things a stupid animal;"—again, "instead of being the exceptionally wise animal, as it is believed to be, its sagacity is of a very mediocre description;"—once more, "it has a large share of the ordinary cultivable intelligence common in greater or less degree to all animals, but its reasoning faculties are far below those of the dog" (p. 180).—(Sanderson's *Thirteen Years among the Wild Beasts of India*, pp. 78, 80, 81.) As to the whale, we have abundant proof of its strong affection to its young; we know, besides, that it has great quickness of vision; but as to its intelligence, there is little available evidence.

The outstanding characteristic of these two animals is enormous muscular power, the one being capable of carrying half a ton when on the march, and even a ton for short distances (p. 176); the other being capable of propelling itself through the water with marvellous velocity, and able with a stroke of its tail to endanger a ship. In this connection, the ape, with its strong nerve fibres, must be re-introduced, as affording additional illustration of elaborate brain structure associated with great muscular power. These three animals taken together, favour the conclusion, that large development of brain, apart from marked development of sensory apparatus, is prominently connected with the functions of the motor side of the nerve system. Conversely, in cases of great muscular development, connected with high brain organisation, the organism does not at the same time possess high sensory development and in such cases intelligence is less than brain development, in itself considered, would lead us to expect. That is to say, a comparatively limited range of sensory impressions along with visceral excitation, may provide the stimulus needful in an organism distinguished for large muscular proportions; and such organism affords comparatively slight inducement to co-ordination of sensory impressions.

With the data now at command, we are prepared for an attempt to reach general conclusions, to which a position may be assigned in the construction of a theory of animal intelligence. These conclusions may be best indicated by separate statement under the distinct branches of the inquiry just closed.

STRUCTURE AS RELATED TO INTELLIGENCE. We reach first a *negative* conclusion, that Intelligence does not always appear in a relation proportionate to cerebral development. The ant is superior in intelligence to the ox; and the dog to the horse; and both ant and dog are superior to the ape. If the evidence be clear and sufficient, a favourite conception among neurologists must be greatly modified. Hitherto our inquiries have been at fault by too much concentration on the brain.

In *positive* form the general conclusion warranted by the evidence is, that Intelligence is according to the development of sensory apparatus, along with development of brain; and that of these two, the sensory apparatus is fundamental, so that deficiency in this could not be compensated by fuller cerebral development. The ant and the bee are similar in brain, yet the ant is more intelligent than the bee, and the difference between the two is in the sensory apparatus at command. This law is further illustrated by the difference between the monkey and the ape.

TESTIMONY FROM NATURAL HISTORY OF ANIMALS. This is best presented under contrasts afforded by animals domesticated for the service of man. In view of facts connected with the housing and training of animals, we are led to classifications quite distinct from those determined by comparative structure; and also varying considerably from the classification which makes account only of intelligence. Of the animals domesticated for the service of man, these may be named, the chicken, cat, dog, cow, horse, and elephant. The animals not domesticated, or kept only on account of interest in questions of natural history, are the ant, monkey, and ape. The intelligence of the ant here stands out more strikingly on account of the complete absence of training by man, and even of interposition on the part of man. On the other hand, the low intelligence of the monkey and ape is the more remarkable because of the striking similarity to man in structure of both body and brain in both animals.

As to attained results, the pre-eminence of the dog among domesticated animals, is that which calls for fuller explanation. Towards this, the following points contribute,—the animal's affectionate disposition; his felt dependence on man, far surpassing anything recognised by the horse or ox; his size, any great increase in which would prove restrictive; his closer companionship with man, and life in the home of man, from which the horse and ox must be excluded, yet to which the cat is welcomed, with comparatively slight intellectual advantage, inasmuch as the dog is far more guided and controlled in his movements by man.

EVOLUTION AS CONCERNED WITH INTELLIGENCE. Evolution of organism and of intelligence do not so harmonise that progress in the one can be a sure index to progress in the other. Evolution of organism determines notation on the scale of animal existence; and evolution of brain is according to comparative advance in bodily structure; but we cannot say that evolution of intelligence is carried forward with these movements, or practically included in them. Of the evolution of intelligence we cannot speak apart from references to the comparative sensory apparatus, and the natural disposition of animals.

INSTINCT AS A SPECIAL FEATURE IN ANIMAL LIFE. It has been apparent throughout, that certain forms of instinct belong to animal life in all its types; that instinctive actions are essentially different from actions attributed to intelligence, thereby requiring, as Mr. Herbert Spencer says,[1] rejection of popular usage, which refers all animal intelligence to instinct; and that the contrast consists in this, that instinctive actions are done from the first with accuracy, independently of individually acquired experience. Instinct is, therefore, a predisposition to action, inherent in organism, and fulfilling its part as an impulse without training, under fixed organic conditions. Mr. Darwin, without defining Instinct, is content to say that "it will be universally admitted that instincts are as important as corporeal structures for the welfare of each species, under its present conditions" (*Origin of Species*, p. 206). We may define instinct in the most general terms as organic impulse essential to distinct forms of animal life. But there is need for distinguishing a certain number of impulses which act quite blindly, as the appetites, hunger, thirst, and sex, from others which seem at least to us, whether accurately or not may be hard to determine, to involve some discrimination as to the end contemplated, as in the building of nests by birds, and drying of corn by ants. Evidence is decidedly in favour of Mr. Darwin's position that the natural instincts of animals are capable of slight modifications under changed conditions of life; and concerning certain instincts the position of Mr. Herbert Spencer, that they are the result of early acquisitions hereditarily transmitted, has much in its favour, being supported by the history of different breeds of dogs and pigeons. To this class of instincts also belong the impulse to concealment under sense of danger, in the case of the chick at sight of a hawk, and of grouse at flight of any large bird, such even as a heron; and the stillness of a swarm of croaking frogs when an owl appears overhead (*Life of Edwards*, p. 123). Mr. Spencer's description of Instinct as "compound reflex action," well describes the mode of action, but is not sufficiently discriminative; for, the great majority of the more striking examples of intelligence in animals are clearly "compound reflex actions."

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[1] *Principles of Psychology*, i. p. 432.

ANIMAL INTELLIGENCE AS DISTINGUISHED FROM INSTINCT. The essential distinction between these two appears in its simplest form in the contrast between outward observation and internal impulse to action. The difference may be illustrated by the dog watching the approach of his master, and turning round and round before he lies down. Towards the interpretation of this difference, it will be helpful to notice as a preliminary fact, that the one is connected more obviously with the motor system, the other with the sensory. That this involves an inherent difference in the law of cerebral action, is favoured by the view already insisted upon as to the dependence of animal intelligence on the sensory side of the nerve system. Instinctive action originates from within, having its rise determined by certain conditions of the organism, just as visceral excitation leads to muscular activity, for it is true, as Mr. Spencer says, that instincts "occur only among the actions of that nervo-muscular apparatus which is the agent of psychical life." Actions illustrative of animal intelligence are such as depend on sensory impression made upon external organs of sense, and more commonly through the special senses. But the distinction is difficult to maintain clearly, a difficulty readily appreciated if two facts are considered, that all sensory impression from without tends naturally in animal life to pass over into action; and that repeated impressions when thus associated with motor action, produce an organic change in the cerebral organ (p. 230), and by hereditary transmission pass over into the region of instinct (p. 262). The pointer affords a ready illustration. But this latter fact, that in the history of a race or breed of animals an impression once strange may work in upon the structure of the brain so as to become an inherited instinct of organism, shows the *historical distinction* between animal intelligence and instinct; and at the same time the *closeness of organic relation* between these two.

INTERPRETATION OF ANIMAL INTELLIGENCE. We have now to inquire what explanation can be offered of the facts classified under Intelligence. In prosecuting the subject, we must start with the distinction between reflex action as discriminative yet mechanical, and intellectual activity as known in human experience, and which need not be concerned with muscular activity. This distinction is stated p. 203, and the contrast involved, p. 204. As concerned with muscular activity, I have ventured to express the distinction sharply in the proposition that reflex action is the antithesis of intellectual action. We now reach the point for dealing with the inquiry, What is meant by Intelligence as attributed to animals; and how does this Intelligence stand related to the functions of Brain?

Having an exact definition of reflex action, as common to all nerve systems, advance can be best made by inquiring how far sensori-motor action carries an explanation of the phenomena ascribed to Intelligence. Reflex action is that in which motor apparatus responds to sensory impressions, or that in which molecular movement is extended from one side of a nerve system to the other. In the higher vertebrates, reflex action does not necessarily imply cerebral action. As in lower orders of life, sensori-motor action is possible, even when the central organ is a small ganglion, so is it possible in all animals possessed of a brain, without intervention of the central organ. This, then, is mechanical action, or action of the mechanism of the living body. It is motion roused by external excitation, propagated along a sensory nerve passing through a nerve centre, into a motor nerve, resulting in motor activity. Our question is, How much of the activity in animal life, popularly assigned to Intelligence, can be included within reflex or sensori-motor activity in the nerve system?

A first step is secured by observing that reflex action is precisely the same in nature, whether it passes through one of the lower nerve centres, or through the brain. In the latter case the action is more extended, and involves more complex apparatus, but the form of action is nowise different. Thus, in the human body, the form of nerve action is the same whether propagated through the spinal cord, or through the medulla, or through the brain itself. The only difference is that the lower the centre, the simpler the action; the higher the centre, the more complex the action. Advancing complexity of movement requires only increased complexity in apparatus.

Here we encounter a pressing difficulty in comparing animal with human activity. We must introduce reference to "consciousness," which has been hitherto avoided. A distinction as to the action of sensori-motor apparatus can be taken in the case of man, which cannot be established in the case of animals. Through one of the lower centres, reflex action takes place of which we have no consciousness, and for this set of actions we can reserve the name "reflex." On the other hand, when movement passes through the brain, and is thence extended to the muscular system, we are conscious of the impression made on the sensory system, and to such action we have been accustomed to reserve by contrast the name "sensori-motor." This action is still purely an action of the mechanism of the body, for, as Professor Huxley recognises,[1] the will has no concern with it, and the action may even occur in opposition to personal determination, as in the winking of the eyes, when an object is swept suddenly past the face. With this action the "mind" has no concern, save that it is *cognisant* of the occurrence. Hence there is a possible distinction as concerns human life, between "reflex" actions and "sensori-motor" actions; a distinction which cannot be shown to hold in the case of animals, even the most advanced in organism. But besides, it is an unwarranted distinction physiologically, even as applied to human action, and unfortunately tempts us to draw up into the region of "mind," what belongs exclusively to the mechanism of the body, and leads to that description (already criticised, p. 205) of the actions of the sensory organs as properly "spiritual affections" in view of those holding the existence of a distinct mind or soul. To distinguish, therefore, even in human life, between "reflex" actions and "sensori-motor" actions, as if they were separate classes of actions, is without physiological warrant. It is doubly objectionable, first, as suggesting a difference of function, where none exists; and secondly, as importing a meaning into the word "sensory" which it cannot bear, and which neurology is bound to resist, for it is drawing into the word "sensory" the additional fact of "consciousness," which in its proper physiological sense, as applicable to the one side of a nerve system, the word "sensory" cannot bear. Granting for a moment the distinction, which is easily recognised in human experience, inasmuch as consciousness is the condition of our experience, it is manifest that all "reflex" action is sensori-motor; and all "sensori-motor" action is reflex. Neither can evidence be presented, nor argument be constructed, to the contrary. The first principles of neurology require its rejection. All muscular movements in which the motor system responds to the sensory system are reflex actions, and their explanation is wholly mechanical and physiological.

The ground being thus cleared, we are prepared for the first serious perplexity—Are animals conscious of sensory impressions, as we are? The question is difficult to answer, for we are without direct evidence on the subject. Professor Huxley says, "It must be premised, that it is wholly impossible absolutely to prove the presence or absence of consciousness in anything but one's own brain, though, by analogy, we are justified in assuming its existence in other men" (*Science and Culture*, p. 217). This makes the perplexity wider than it is, for there is no uncertainty as to the consciousness of our fellow-men. Use of language puts doubt out of account. But there is no possible method of proving that animals are conscious as we are. Even by the most extreme test, destruction of the anterior division of the brain, nothing is proved but loss of sensory power, while there is continued possibility of motor activity. Professor Huxley has described the results in the case of a frog: "Suppose that only the anterior division of the brain—so much of it as lies in front of the 'optic lobes'—is removed. If that operation is performed quickly and skilfully, the frog may be kept in a state of full bodily vigour for months, or it may be for years; but it will sit unmoved. It sees nothing, it hears nothing. It will starve sooner than feed itself, although food put into its mouth is swallowed. On irritation, it jumps or walks; if thrown into the water, it swims. If it be put on the hand, it sits there, crouched, perfectly quiet, and would sit there for ever. If the hand be inclined very gently and slowly, so that the frog would naturally tend to slip off, the creature's fore-paws are shifted on to the edge of the hand, until he can just prevent himself from falling. If the turning of the hand be slowly continued, he mounts up with great care and deliberation, putting first one leg forward and then another, until he balances himself with perfect precision upon the edge; and, if the turning of the hand is continued, over he goes, through the needful set of muscular operations, until he comes to be seated in security upon the back of the hand. The doing of all this requires a delicacy of co-ordination, and a precision of adjustment of the muscular apparatus of the body, which are only comparable to those of a rope-dancer" (*Ib.* p. 221; Foster's *Physiology*, p. 608). This case takes us to the extreme margin of possible experiment, and the results appear adverse to the hypothesis that animals have consciousness, or that what is true for man is true for other vertebrated animals. The results are partial loss of sensory power, and continuance of motor power, even to the extent of complex co-ordinated action of muscles. The effects of similar injury to the human brain are such that in similar circumstances man could not do what the frog does. From this, the most probable inference is, that co-ordinated muscular action in the animal is not dependent on consciousness, as in man. On the other hand, as the cerebral conditions of co-ordinated action may be held to be analogous in all organisms, the results render it probable that a large amount of co-ordinated muscular activity in human life, which we have commonly regarded as involving intelligence, takes place quite independently of intelligence. The frog, even when deprived of "the anterior division of the brain," can perform co-ordinated muscular actions "which are only comparable to those of a rope-dancer." How, then, would it be with a man who had sustained analogous injury to the brain? Evidence is quite conclusive against the possibility of similar action under any approach to similar conditions. Professor Huxley gives his testimony explicitly in the following sentences. "If, by some accident, a man's spinal cord is divided, his limbs are paralysed, so far as his volition is concerned, below the point of injury; and he is incapable of experiencing all those states of consciousness which, in his uninjured state, would be excited by irritation of those nerves which come off below the injury. . . . However near the brain the spinal cord is injured, consciousness remains intact, except that the irritation of parts below the injury is no longer represented by sensation. *On the other hand*, pressure upon the anterior division of the brain, or extensive injuries to it, *abolish consciousness*" (*Science and Culture*, pp. 217, 218). Now, in the unconscious state, a man is incapable of co-ordinated muscular activity. An animal, however, after having been deprived of the anterior division of the brain, can maintain complex muscular activity. Hence, it seems highly probable that in animals co-ordinated muscular activity takes place without consciousness, while similar actions in human life imply consciousness, and are impossible if the anterior division of the brain be rendered functionally inactive.

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[1] *Science and Culture*, p. 210.

Closer examination of the frog's case appears to supply additional evidence favouring this conjecture. There is not a complete loss of sensibility. The special senses are rendered inoperative, but general sensibility as connected with the motor system remains. The animal is blind and deaf, but it is sensitive to external excitation, inducing it to jump, walk, or swim. So much of general sensibility as is needful for stimulation of the motor system continues; but the possibility of such sensory action does not induce motor activity. The animal remains motionless. If, then, a sensibility which can be brought into exercise only by external contact is sufficient to provide for complex motor activity,—and if such sensibility continues operative when the special senses have ceased to fulfil their functions,—these facts seem to favour the conjecture that co-ordinated muscular activity is independent of consciousness.

Still, in the absence of direct evidence, nothing more than a probability can be stated. But if any estimate of probabilities is to be attempted, we must shun the tendency to identify sensory activity with consciousness. The need for this is manifest, for there is no doubt of sensibility in the case supposed, while there can be nothing higher than conjecture as to consciousness. The animal swims when thrown into the water as a direct consequence of sensory activity, just as we continue to walk after having once started, without direct volition, and consequent only upon sensory impression. But it must be admitted to be impossible to obtain direct evidence to settle the question whether consciousness belongs to animals in general, or to certain classes of animals, such as the higher vertebrates. In human life it is beyond doubt that these two things are true,—that our sensory apparatus is thrown into functional activity by external excitation,—and that we are conscious of sensory impressions so produced: whereas in animal life only the first of these is matter of certainty.

In order to avoid an obscurity which is apt henceforth to cling to the whole discussion, because of the admitted impossibility of having direct evidence of the presence or absence of consciousness in animals, it is needful here to have a clear statement of what consciousness as exercised by us involves. Consciousness is illustrated in the knowledge of a sensation as a present experience in our own life. It involves knowledge of our own existence, and of the state of that existence at the moment. Further, consciousness belongs so much to the very nature of intelligence, as to imply knowledge that the present experience is not the result of our own effort. It thus supplies the test on which we seek an external explanation of present experience. This explanation we find in external excitation, which physiology represents as the condition of sensori-motor action. Apart from the distinction in consciousness between self and not-self, an explanation of sensori-motor activity could not be attempted. Further, the explanation sought cannot be found without use of one of the special senses,—either sight or touch,—along with the natural action of some of the sensory and motor nerves. The power of comparing things is thus essential for interpretation of sensori-motor action, and this power of comparing is the distinguishing characteristic of "Mind." We may, therefore, say that consciousness is a function essential to Mind, so that wherever Mind is, consciousness is a condition of its functional activity; and conversely, wherever consciousness is impossible, mental action is impossible. If, therefore, it is doubtful whether animals possess consciousness, it is doubtful whether they possess mind. If some of them are conscious, some of them possess minds. In this connection, Professor Huxley says, "If they possess immaterial subjects of consciousness, or souls, then, as consciousness is brought into existence only as the consequence of molecular motion of the brain, it follows that it is an indirect product of material changes" (*Science and Culture*, p. 238). This statement is obscure, and, in the only sense worth considering, the inference cannot be accepted. If it be meant that consciousness includes experience which is consequent on the action of sensory apparatus, the statement is a truism. It cannot be meant that consciousness is a function of sensori-motor apparatus, for human life affords direct proof to the contrary, in reflex actions which do not give rise to consciousness. If it be meant that consciousness is a function of molecular motion in the brain, there is no evidence for the statement. There is strong evidence against it. Certainly, we are not conscious of molecular motion in the brain, and we have no direct knowledge of its occurrence, for we have no sense which includes such motion within its sphere. If, then, we say that consciousness is "the indirect product of material changes," as it is "the consequence of molecular motion of the brain," we mean that it is the consequence of such motion, just as it is the consequence of motion of a sensory nerve, and just as it is the consequence of external excitation of the periphery; and there is no warrant for saying more in the one case than in any of the others. Molecular motion in the brain is that material change which is nearest in time to the act of consciousness attendant on it; but it is no more the cause of consciousness than the others are; it is the antecedent and essential condition of the particular experience, just as the others are, and in no other sense. The molecular movement in the brain is only an integral part in a continuity of movement, started at the periphery and continued to the sensory cell. No doubt, consciousness is connected with movement in the brain, as the last or nearest part of the movement; but what does this involve as to the relation between the two? Sensori-motor action provides materials for a reply. As the whole course of sensory motion is from the periphery to the brain; the whole course of sensori-motor action is from the periphery through the brain to the muscle. Consciousness gives us no knowledge of this movement propagated from extremity to extremity through the central organ, nor of any part of it. But there is consciousness of a sensation consequent on external contact; and consciousness of another sensation consequent on muscular movement, and dependent on sensory nerves connected with the muscle. Now, these two phases of consciousness are not a part of the movement performed by nerve apparatus. Sensori-motor activity through one of the lower nerve centres, such as the spinal cord, affords illustration. If, then, we interpret the functions of all nerve centres on the analogy of the lower, allowing for growing complexity as we ascend; that is, if we interpret the functions of nerve cells on the same rule as that on which we interpret nerve fibres, accounting their functions the same, however complex their relations; it will follow that consciousness is no part of the nerve movement, and is not a function of nerve cells.

Next, let us shift the point of observation. Consciousness makes account of an impression at the periphery, and of another impression connected with the working of a particular muscle, or set of muscles. But it makes no account of the propagated sensori-motor molecular movement, either at its rise, or in the line of its progress, or in its reception. All that concerns such movement is a quite recent discovery in physiology. But consciousness is concerned with what takes place at the opposite extremity of the nerve line from that at which the "message" is delivered. This is so singular and striking a feature in the case, that it led to the assumption of early psychologists that the mind was present throughout the whole body, and though we now regard this as an unwarranted hypothesis, we must not overlook the fact on which its suggestion rested. For it is needful now to seek escape from another assumption, no less a fallacy, that consciousness makes account of what occurs in the brain. On the contrary, it is cognisance of what takes place at the peripheral extremity of the sensory nerve. How this is accomplished, it is impossible to explain; but the fact is certain, and in this we have evidence that consciousness is a phase of intelligence in the higher sense meant when we seek an explanation of physical experience. Such is consciousness in us; that there is any such consciousness in animals, there seems no evidence to prove.

In accordance with this view, there is abundant evidence to show that animals do not interpret their experience as we do, and that what we designate "Animal Intelligence" is merely the discriminative and purposive activity of the nerve system, when such activity involves co-ordination of nerve movement pertaining to the special senses.

There is with animals, as with us, a lower phase of sensori-motor activity, to which we do not attribute intelligence, and which we are accustomed to describe as "unconscious." But in our use of this term, we draw on the analogies of human life, and are seeking to make distinctions which we have no reason to suppose have any application in animal life. To this lower phase must be referred, for example, the frequent use of the tail in the horse and the ox, and, still more conspicuously, in the dog, though to us with our habitual exercise of intelligence, ever interpreting our observations, the action of the tail seems often in the dog's case a language in itself, inasmuch as we have come to observe that such action is co-ordinated with certain states of feeling in the animal. Another set of examples we have in the rise and fall of the ears of animals. We do not attribute intelligence to such actions, for the actions are unmistakeably sensori-motor, yet, resorting as usual to the analogies of our own experience, we say that the animal's "attention" is arrested.

A general classification of actions popularly assigned to Animal Intelligence is attained when we include all action of the sensori-motor system, which is co-ordinated with action of the special senses, and more particularly of sight and hearing. When an animal grazing comes upon some shrub, or stretch of grass, for which it has a special fondness, we do not attribute its eagerness to intelligence. But when this animal is arrested by the movement of some object at a distance, and goes towards it, and stands at a little distance watching it, we are more disposed to regard such conduct as indicative of Intelligence. Yet, the one set of actions is just as truly sensori-motor as the other. Thus it appears that we quite naturally incline to attribute intelligence to animals, when their conduct illustrates co-ordination of two or more of the special senses. The popular view is largely directed by analogies of human life, in ignorance of the physiology of the nerve system.

The use of the sense of smell in animal life presents some specialities in our modes of interpretation. We do not in our own life attribute high intellectual value to this sense; on the contrary, we place it low in the scale of intellectual relations. In accordance with this are our estimates of the actions of animals plainly dependent on this sense. If a dog turn aside to examine a dead mouse, or rat, we think nothing of it. We do not attribute to the animal any leanings towards studies in natural history. But, if the animal is guided by the same sense to the discovery of a lost article which we cannot find, or towards a locality the direction of which is a matter of uncertainty to us, we attribute such actions to intelligence; and we do so erroneously, because of our ignorance of the manner in which the animal is guided. Did we recognise that the sense of smell provided as surely for the more startling line of conduct, as it does for the more ordinary, we should cease to report these cases as wonderful examples of animal intelligence. We should then recognise that superior knowledge of the dog is only superior sensibility of the olfactory apparatus—a superiority which does not in itself bear witness to intelligence. Thus, from a case apparently most favourable, we are warned of a danger of false inference besetting our observations. Even with sensory superiority, evidence for intelligence can be found only by reference to the use the animal makes of its susceptibility. Sensibility and intelligence are distinct, presenting rival tests of action. The ant has superiority in *touch*; our finest tactile sensibilities are blunt in comparison. In sense of *smell*, both the dog and the horse are superior to man. The dog will find a lost article for which we search in vain; yet smell is that sense which, in our own experience, depends least upon intelligence for its exercise. The dog's discovery of his master in a crowd is evidence only of smell power. In view of the complexity arising from two standards of guidance, we are thrown back on our definition of human intelligence, as a power perceiving differences between present and past impressions, comparing these, and drawing inferences. Allowing to animals superiority in structure of sensory apparatus, and, therefore, superior sensibility, we thus account for actions clearly surpassing those of man, without attributing to the animal comparison of present with past impressions.

Passing next behind sensory apparatus to the central organ—the brain—we have to enquire how far brain structure may account for relative superiority in intelligence. Complexity in sensory apparatus itself implies superiority in brain structure. As the olfactory tract in the dog is superior to that of man, the dog's brain is superior to the human brain in the correlated portion. Reference to the central organ thus far supplies nothing new as to range of activity. The outer and the inner are in agreement. There is a double index-dial, connected by a single line, providing for an identical record on both. Special terminal arrangements in the periphery have appropriate structural arrangements in the brain, correlated with other portions of the central organ. Further enquiry must be guided by reference to additional features in the structure of the brain. Our first clue must be sought in connection with combination of parts in the central organ, our second in diverse structure of nerve cells. Evidence as to mind-action, adduced from *human life*, must be reserved for the next chapter.

Correlation of parts in the central organ can, however, yield nothing beyond indirect testimony. Combination of sensory and motor apparatus, being essential to all organism, yields no evidence as to intelligence. According to complexity of organism, there must be complexity of central organ. This is the principle of brain-structure. Hence nerve lines of co-ordination are multiplied within the central organ, according as sensory and motor apparatus are amplified in the organism itself. Full provision for the sensori-motor system must first be recognised before we can search for testimony in favour of intelligence. Such testimony, if found, will be most likely to appear in relation with the *motor system*, because we are seeking evidence of an additional source of activity—mechanical appliances being operated upon by some distinct power. Yet additional apparatus may not be needful. We naturally ask, however, whether motor centres are more numerous than sensory apparatus requires. Such enquiry proceeds upon the hypothesis that, in some cases, "psychical functions" are prior to sensory impressions—possibly even awakening sensory activity as well as motor—and are thus superior to sensori-motor functions. If intelligence implies comparison of present with past experience, the hypothesis of priority of mental action is granted. In seeking structural evidence of "psychical functions," we therefore seek, in the first instance, new motor centres, for intelligently-directed activity. Apparatus for co-ordination can afford only secondary evidence. We are still, however, without proof of the existence of centres reserved for the executive function under intelligent direction. Though there are portions of brain which are "silent" under electric excitation, the probability is that these are sensory centres.

Can we advance a step further, to include "mind cells"? Intelligent direction of activity must imply motor cells, either appropriated, or used conjunctly for sensory and mental excitation. Either alternative is possible, for there is nothing peculiar in the supposed motor action itself, but only in its source. In this case "mind cells" might be cells "commanded by the mind." That there are such cells is admitted when reference is made to voluntary muscular activity. But a much more difficult question is raised when it is asked—May there be cells performing "psychical functions"? This hypothesis would imply that these select cells perform neither sensory functions, nor motor, but functions superior to both of these. Classification because of difference of function is granted. Yet it does not seem that difference of function implies difference in cell structure, but only difference of relation, thus suggesting that both sensory and motor functions are forms of motion, though in distinct relations. Classification of sensory and motor cells is clearly warranted on experimental evidence,[1] but we are without evidence for classification of "psychic cells." Search here becomes attracted by greater size, special position, and manifold lines of communication. Of the cells known on account of their shape as "pyramidal cells," some are named "giant cells." Reference to fig. 7, p. 26, and to fig. 48, p. 299, will show the characteristics of such cells as they appear in the human brain. Reserving more detailed discussion of the probable functions of these pyramidal cells, it is to be remarked that pyramidal cells are found even in the brain of fishes.[2] Their appearance so low in the scale tells heavily against the hypothesis of "psychic functions." On the other hand, the number of processes or fibres issuing from these cells favours the view of a larger amount of work, and proportionate nourishment. Granting at least to the higher vertebrates a measure of intelligence, though quite inferior in character to rational intelligence in man, we are without evidence of the presence in the central organ of "psychic functions" accounting for this intelligence. Our problem must, therefore, be held in reserve until we include the additional testimony which may be gathered from human organism and activity.

From structure we must turn to the ordinary life of animals for some clearer estimate of the "intelligence" attributed to them. We take the test of *language*, to which special attention has recently been given. The experiments of Professor

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[1] Chapter iv. Localisation of Functions, pp. 79-122.

[2] Owen's *Comparative Anatomy of Vertebrates*. Haeckel's *Evolution of Man*, I., p. 128, translation.

R. S. Garner, Virginia, are of value here.[1] In dealing with the "natural language" of animals, we must distinguish between tactual communication and vocal. All animals communicate with members of their species through sensory apparatus. Thus, we have had to speak of "the antennal language" of ants,[2] for these animals communicate with each other by the organs of touch (fig. 43, p. 211). The mere fact of communication naturally induces us to speak of "the intelligence of ants." When we pass to vocal communication, we include all animals from the bird upwards. Every sound uttered by an animal expresses some feeling natural to it. Any such sound falling upon the ear of another of the same species awakens similar feeling. All this, however, belongs to the region of sensibility, and is independent of intelligence. The purr of a cat, the neighing of a horse, and the wag of a dog's tail are equally good illustrations of expression of feeling The cackle of the hen, the bleating of sheep, the lowing of oxen, are equally effective. The feelings are common; the vocalising only is different.

Professor Garner's study of "the Simian tongue" affords a helpful guide to enquiry. His plan is imitation of vocal expression—test of accuracy by repetition of the sound in hearing of the animal—use of the phonograph for experiment on the animal's ear—interposition of his own imitative effort, or of the phonograph, for communication between mates—and reference of the sounds to animal wants or to objects. The method is admirable, and results are clearly recorded, with the piquancy of a delightful exuberance of feeling, in prospect of sudden enlargement of the area of philology.

The sounds emitted by animals are sounds of recognition, of desire, of gladness, of fear. They express feeling natural to the animal in its relation to others of its kind, or to animals which are natural enemies. They indicate unsatisfied want, or want appeased. Does intelligence appear in the use of "animal language"? Professor Garner, as the imitator of monkeys, becomes an adept in the use of "the Simian tongue." This imitative art is analogous to that of the bird-trapper, who lures birds by imitation of their calls. Edwards had a large part of his success as a naturalist from his knowledge of sounds, which he could interpret throughout the darkness.

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[1] The *New Review*, No. 25, June 1891, p. 555.

[2] P. 213. Huber's *Natural History of Ants*, p. 154.

Regarding "the task of learning the monkey tongue as very much the same as learning that of a strange race of mankind," Professor Garner visited the zoological gardens in New York, Philadelphia, Cincinnati, Chicago, and Washington, to gain acquaintance with Simian "native tongues." The capuchin monkey (*cebus capucinus*) was preferred by Garner, on the same grounds as determined the preference of Romanes for the brown capuchin (*cebus fatuellus*) (p. 256)—docility and intelligence. Garner says, "My work has been confined chiefly to the capuchin monkey, because he seems to have one of the best-defined languages of any of his genus, besides being less vicious and more willing to treat one civilly."

The difficulties of the study of the Simian tongue proved to be many. "One difficulty was to utter the sounds I heard; another was to recall them; and yet another was to translate them." The main difficulty was overcome by aid of the phonograph.

The first important experiment was made in conjunction with Dr. Frank Baker, Director of the National Zoological Gardens, at Washington. "We separated two monkeys which had been caged together, and placed them in separate rooms. I then arranged a phonograph near the cage of the female, and caused her to utter a few sounds, which were recorded in the cylinder. The machine was then placed near the cage containing the male, and the record repeated to him, and his conduct closely studied. The surprise and perplexity of the male were evident. He traced the sounds to the horn from which they came, and, failing to find his mate, he thrust his head and arm into the horn quite up to his shoulder, withdrew it, and peeped into the horn again and again. He would then retreat, and again cautiously approach the horn, which he examined with evident interest. The expressions of his face were indeed a study. Having satisfied myself that he recognised the sounds as those of his mate, I next proceeded to record some of his efforts, but my success was not fully up to my hopes. Yet I had secured from him enough to win the attention of his mate, and elicit from her some signs of recognition. And thus, for the first time in the history of philology, the Simian tongue was reduced to record." For the first time, a monkey's call had got into a phonograph; and when the sound was reproduced from the cylinder, her mate was affected by it just as he would have been had the sound come direct. Reproduced sound is to the monkey the same as the original sound.

A more important experiment is that concerned with interpretation of the sounds. Professor Garner was successful in identification, though by a circuitous route. He says, "I uttered the sound which I had translated 'milk.'" After a time the monkey answered with the same sound, and brought the pan from which he was wont to drink. Milk was given him in the pan, which he drank with zest, afterwards seeking and getting more. The same experiment was repeated in the garden at Cincinnati; the animal replied in like manner, bringing his pan to the edge of the cage. The keeper had no milk. A glass of water was brought. His efforts to secure the glass "were very earnest, and the pleading manner and tone assured me of his extreme thirst." He was allowed to dip his hand into the glass, "and he would suck his fingers, and reach again." "I was thus convinced that the word I had translated 'milk' must also mean 'water,' and from this and other tests I at last determined that it meant also 'drink,' and, probably 'thirst.'" The sound clearly was the natural expression of thirst, and meant neither milk, nor water, nor drink.

Professor Garner next refers to "a word which was very hard to render well, but I translated it 'to eat.' I now held a banana in front of the cage, and he at once gave the word I had described. Repeated tests showed me that he used the same word for apples, carrots, bread, and banana, hence I concluded that it meant 'food' or 'hunger,' and also 'to eat.'" We have here obviously the natural sound of desire under hunger. That the sound named the things cannot be maintained, since the same sound was emitted whatever the object presented. These two examples show that the animal has a natural sound expressive of thirst, and another of hunger. This seems to hold true of many animals, though a single sound often expresses both. A horse in his stall will neigh whether water is being brought, or corn.

The monkey has also a distinct sound for fear. The experiment connected with use of this is so interesting that we give the narrative in full. "Another sound I suspected was a 'menace' or 'cry of alarm,' but I was unable to utter it except with the phonograph;[1] but during February I had access to a fine specimen of the capuchin in Charleston, South Carolina. On my first visit to him I found him very gentle, and we at once became good friends. He ate from my hands, and seemed to regard me very kindly. The next day, while feeding him, I uttered the peculiar sound of 'alarm,' whereupon he sprang at once to a perch in the top of his cage, and as I continued the sound he seemed almost frantic with fright. I could not tempt him by any means to come down. I then retired some twenty feet from the cage, and his master (of whom he was very fond) induced him to come down from the perch, and, while he was fondling him, I gave the alarm from where I stood. He jumped again to his perch, and nothing would induce him to leave it while I remained in sight. The next day, on my approach, he fled to his perch, and I could not induce him on any terms to return. It is now some time since I began my visits, and I have never, since his first fright, induced him to accept anything from me, and only with great patience can I get him to leave his perch at all, although I have not repeated this peculiar sound since my third visit; nor can I again elicit a reply from him when I say his word for 'food' or 'drink.'" "This sound (of alarm) may be fairly imitated by placing the back of the hand very gently to the mouth, and kissing it, drawing in the air and producing a shrill, whistling sound, prolonged, and slightly circumflexed. Its pitch is the highest F sharp on the piano. It is not whistled, however, by a monkey, but is made with the vocal organs."

These observations were skilfully conducted. The results give clearly distinguished sounds for thirst, hunger, and alarm, —natural feelings which commonly have expression with the higher vertebrates.

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[1] The security of animals consists, to a considerable extent, in the difficulty of imitating the sounds they use.

In the use of these sounds, evidence of intelligence is slight. The lifting of the pan for milk shows, however, some intelligence as to the use of means, and there is a fondness for those showing kindness, which may aid in training; but these experiments guide to no results in advance of those obtained by the observations of Buckland, Romanes, and others. There is nothing here to show that sounds or words indicate things, or pass beyond the manifestation of feeling. When milk, water, drink, thirst are taken indiscriminately in one case; and apple, carrot, bread, banana, food, hunger, eat are taken in another, it is clear that observation is being turned aside from the key of interpretation. The reference to a supposed object is misleading; the sound is the expression of felt want. The fact that the monkey had his want met by water, as readily as by milk, is conclusive; in the other case all varieties of food meet the call given. The animal when thirsty emits a particular sound; when hungry emits a sound of distinct character; and by a shrill whistling sound gives warning of danger.

Much clearer evidence for animal intelligence is found when we estimate the results of human training. The monkey seems to have greater quickness, and certainly greater curiosity, than any other animal whose habits have been closely observed; but its whole conditions of life make its training a hopeless task. However tame, it is apt to prove treacherous, while it is always mischievous and destructive. There seems, besides, no hope of improving the race by sending the tamed monkey among the untamed, for the others at once attack and destroy the deteriorated specimen. Monkeys are opposed to "innovations."

Our best results are gathered from the history of training in the case of the horse and of the dog. The dog stands pre-eminent. In what he now is, we see the results of many hundreds of years of training under the care of man, and these results are sufficiently striking to determine our conclusion. Here the evidence seems conclusive that a subordinate type of intelligence belongs to the higher vertebrates. The significance of this conclusion needs, however, to be carefully determined in view of the evidence at command. This evidence is not, indeed, by any means so large as we commonly and very naturally take it to be. Knowledge of the sensory apparatus, only recently acquired, enables us to say with certainty, that a large amount of activity, commonly named "intelligent," must be referred to the sensori-motor nerve system. This deduction does not affect the question of animal intelligence; it gives only a more exact understanding of the lines along which the physical and the intellectual meet.

The evidence in favour of animal intelligence reaches its climax in the life of the dog. With none of our domesticated animals has companionship with man been so close. Structural advantages are not so great in this case as in the monkey, but they are more favourable than those of any other animal. Sensory apparatus, specially prominent in the dog, is less favourable than in the case of the monkey, since smell counts for less in training than sight. Both in touch and in sight the monkey surpasses the dog. What the monkey might have been under continuous training for hundreds of years, it is difficult to suppose. The fact remains, that the dog has precedence, and so things will continue. We can, therefore, with certainty conclude that the whole question of animal intelligence may be advantageously discussed by analysis of evidence supplied in the life of the dog. In so deciding, we do not place the dog in all respects at the top of the scale, remembering structural differences, but we have a sufficiently clear order of arrangement. Looking down the scale on which man has the chief place, we have rational, intelligent, sensori-motor, and motor activity—stretching from human life to simple protoplasm. Looking from below upwards, we see the relative advance in the history of life.

The whole evidence may be tested by reference to the aptness of the dog to interpret the language of man. This is the decisive point. There is a certain appreciation of language, not in its meaning, but in its constant association with activity required of the animal. The nature of the dog has "been moulded by human agency with reference to human requirements." (Romanes, "Animal Intelligence.") The dog has shown peculiar aptness for such training, appreciating sounds and signs, and specially, recognising the relation of his own efforts to the ends contemplated by his master. But it is impossible to dissociate the animal from the direction of a master immediately punishing failure, or lavishing favours as the reward of success. Left to himself, the animal soon reverts to natural instincts. A neglected dog loses his aptitudes and takes to hunting on his own account, often tending to become a depredator. But intelligent aptitude is very marked so long as he is kept in training. As the shepherd directs, he will "go wide" to gather stragglers, or come "to heel"; even in the darkness, the dog's bark may be a warrant as good as our familiar "all right" (p. 244); even when barking furiously he will withhold from biting (p. 245); and he will readily learn to associate any new combination of words with his appointed work (p. 246). On evidence such as this, it seems clear that there is in his life something in advance of sensori-motor activity; some subordinate type of mind capable of associating signs and sounds with ends. The limits of his intelligence appear in his dependence upon a master, and commonly upon a single master (p. 245), whose authority is uniform, so that he is slow to accept directions from others. From such evidence, it seems clear that intelligence is not restricted to human life; that it appears in a lower phase in the life of the higher vertebrates, and is developed under human training.

The contrast between animal intelligence and human can be clearly traced by reference to the dependence of the dog on his master, in contrast with the originating and independent power of intellect in man. Our first tendency will be to regard the humbler intelligence as differing *only in degree* from the higher; but evidence fails to sustain this view. No statement of facts illustrating the two phases of activity can be analysed without discovery of an essential difference. The dog shows no power to be his own master in doing the things easily accomplished under man's guidance. A shepherd can have no hope of reaching a point in training beyond which his dog will do everything, and he nothing, in management of the flock. Man interprets his own experience, comparing objects and single qualities of objects, reaching general conclusions applicable beyond the range of his experience. Seeking knowledge for its own sake, man develops his own intelligence. He regulates his conduct on general principles accepted as laws of rational life. These are things unattainable by the animal.

We thus distinguish two orders of intelligence. Animal Intelligence is capable of perceptions and of association of them with action, this association being gained partly under human authority, partly by interest in an end. Human Intelligence sees the general in the particular, and conversely the particular in the general, manifesting thus the essential characteristics of a rational intelligence. Man thinks and acts in recognition of laws of thought and of conduct. Such reflective exercise presupposes rational data, however these have been obtained, whether by the constitution of the mind itself, which I regard as the only adequate theory, or by generalised truths becoming fixed conditions of thought. Under both theories it is admitted that general truth is a necessary condition of rational life. There is a Perceptive Intelligence and a Rational Intelligence. Their analogies are such as to warrant classification under "Intelligence"; but their contrast is such that they must be regarded as distinct types. Human perceptions could never be analogous to those of the animal, nor could the perception of the animal be described as analogous to that of man. The one life is dominated by the Sensory, that is, by the *external* through sensible impressions; the other is governed by rational law recognised as general truth, that is, by *internal* perceptions, incapable of representation through sensory impression. The difference between government by a master, as in the case of the dog, and the mastery of truth, appearing in our application of moral law, is so great as to render it an impossible thing to group the two orders as if the lower were only a less developed stage of the higher.

We have thus come upon the dividing of the ways, determining two distinct lines of observation. There is an Animal Intelligence capable of working up perceptions into associations concerned with want and action; and a Rational Intelligence, including these things, but distinguished by use of general truth for its own guidance.

These two orders of mind are so related that the lower is capable of being utilised by the higher, and thus trained in development of its intelligence, making it more serviceable for human requirements. Great as is the difference between animal intelligence and rational, it is not at all so great as that which separates sensory experience from intelligence; and it does not approach to the contrast between matter and mind. These conclusions have large significance as bearing on the order in Nature. They imply that the appearance of Intelligence is a new start in natural history.

Now, let us seek more definiteness as to animal intelligence, setting in more vivid outline the contrast between dog and man. The traditional view held prior to special research as to comparative structure and function is well stated by Locke: "The bearing of general ideas is that which puts a perfect distinction between man and brute, and is an excellency which the faculties of brutes do by no means attain to. For it is evident we observe no footsteps in them of making use of general signs for universal ideas: from which we have reason to imagine that they have not the faculty of abstracting, or making general ideas, since they have no use of words or any other general signs."[1] We have to consider how far this commonly accepted belief has been affected by recent observations as to what is accomplished by dogs.

In addition to the familiar use of sounds for direction of the dog, the experiments of Sir John Lubbock carry us furthest in use of written or visible signs.[2] These apply to a systematic course of training of a single dog, a black poodle, commonly esteemed the dog cleverest at picking up tricks. Experiments were begun by use of two pieces of pasteboard, the one being blank, the other having "FOOD" printed on it in large letters; the one was placed over an empty saucer, the other over a saucer with bread and milk. "In about ten days he began to distinguish between the two cards." Next, he fetched the cards. The blank when brought was thrown away; when he fetched the other he was rewarded with bread. "In about a month he had pretty well learned to realise the difference. A large number of cards was next used, some to express his wants, others having no such value. These had severally on them the words, 'out,' 'tea,' 'bone,' 'water,' 'door,' 'nought,' 'plain,' 'ball.' It took him longer to realise the difference between words, but he gradually got to realise several, such as 'food,' 'out,' 'bone,' 'tea,' etc. Out of 113 times, he brought 'food' 80 times, 'tea' 31 times, and [one out of] the other 10 cards only twice. Moreover, the last time he was wrong he brought a card—namely 'Door'—in which three letters out of the four were the same as in 'Food.'"

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[1] Essay, Bk. II. Chap xi. § 10, *Of Discerning, and other Operations of the Mind.*

[2] *The Senses of Animals*, p. 277.

These experiments show ability to associate signs with wants, and even in some cases to connect both with a particular object. But they lead no further. As to the use of visible signs, they prove exactly what was shown (p. 246) as to the use of audible signs, "Cow among the potatoes." Beyond this range they do not carry us—association of signs with habitual action. There is no understanding of the meaning of words. "XXX" might as well be printed as "Food,"—the association would be the same to the dog's intelligence if his master preferred the one sign to the other. We are thus without evidence of a conception of a thing, or of recognition of any form of general truth. Mr. Romanes seems to outrun evidence when he says, "All the higher animals have general ideas of 'Good-for-eating' and 'Not-good-for-eating,' quite apart from any particular objects of which either of these qualities happens to be characteristic."[1] All animals distinguish "good-for-eating" from the reverse; sensibility accomplishes this without intelligence; but there is no proof that any animal has a general idea of "good-for-eating," or is capable of classifying things under such a conception. Professor Lloyd Morgan, in his discriminating and lucid chapter on *Mental Processes in Animals*, seems to me to reach the legitimate induction from the facts, when he says, "It is the power of analysis—the power of isolating qualities of objects, the power of forming 'abstract ideas,' that I am unable to attribute to the brute." "We have in the introduction of the analytic faculty so definite and marked a new departure that we should emphasise it by saying that the faculty of perception in its various specific grades, differs generically from the faculty of conception. And believing, as I do, that conception is beyond the power of my favourite and clever dog, I am forced to believe that his mind differs generically from my own."[1]

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[1] *Mental Evolution in Man*, p. 27.

There remains still one line of testimony to be considered—the claim for the dog that it shares in moral nature, and must be credited with possession of a conscience (pp. 239-241). We do not find that there is any proposal to hold a dog responsible for "premeditated wrong"; but it is nevertheless maintained that the dog shows the germs of conscience. Darwin, as we have seen, was attracted by this supposition that "dogs possess something very like a conscience" (p. 241). But the claim fades away before scrutiny of the evidence. The claim is not advanced on the score of intelligence, but of feeling. In every case reference is made to the sense of wrong-doing—the appearance of a feeling of trouble when orders have been disobeyed. The facts are well known. We all know the look of the animal when he has been on forbidden ground, or has done what he has often been punished for. This feeling is identified with remorse, and remorse is attributed to conscience. But this is altogether the result of imputing human reflection to the animal. That such imputation is unwarranted clearly follows from our investigation. The intelligence which perceives things and signs, and associates them with action, may well have such feeling as that described; but such feeling is not conscience, and does not presuppose conscience. There can be no conscience where there is no reasoning as to conduct; even in a rational being that is not conscience which accepts the will of a master as rule. The feeling of the dog depends upon the will of the master. This conclusion is upheld by the whole evidence as to intelligent restraint of the dog, given from p. 236 onwards; and by the observations of Romanes as to the monkey when manifesting signs of shame, p. 256.

The most deliberate vindication of a claim for the higher animals to a phase of moral life is made by Mr. Herbert Spencer, in his work on *Justice* under the title, *Animal Ethics.* It is natural that an evolutionist should trace the ethical thus early in the history of "general conduct." We shall briefly indicate the points in this argument.

In the evolution of conduct, "something which may be regarded as animal ethics is implied." Contemplating "conduct in general," that is, the activity of animal life as a whole, "the highest conduct is that which conduces to the greatest length, breadth, and completeness of life; and by implication there is a conduct proper to each species of animal, which is the relatively good conduct, a conduct which stands towards that species as the conduct we morally approve stands towards the human species." Certain acts of animals excite in us "antipathy or sympathy." This is true even of birds. "A bird which feeds its mate while she is sitting is regarded with a sentiment of approval." "Egoistic acts, as well as altruistic acts, in animals are classed as good or bad. A squirrel which lays up a store of food for the winter is thought of as doing that which a squirrel ought to do." There are "two cardinal and opposed principles of animal ethics. During immaturity, benefits received must be inversely proportionate to capacities possessed. . . Contrariwise, after maturity is reached, benefit must vary directly as worth: worth being measured by fitness to the conditions of existence." "These are the two laws which a species must conform to, if it is to be preserved." "What is the ethical aspect of these principles?" "That without gratis benefits to offspring, and earned benefits to adults, life could not have continued;" "by virtue of them life has gradually evolved into higher forms." On the other hand, to them "has been due the carnage and the death by starvation which have characterised the evolution of life from the beginning," and also the appearance of "torturing parasites." "To those who take a pessimist view of animal life in general, contemplation of these principles can, of course, yield only dissatisfaction; but to those who take an optimist view, or even a meliorist view, of life in general, and who accept the postulate of hedonism, contemplation of these principles must yield greater or less satisfaction, and fulfilment of them must be ethically approved. Otherwise considered, these principles are, according to the current belief, expressions of the Divine will, or else, according to the agnostic belief, indicate the mode in which works the Unknowable Power throughout the universe." "If the preservation and prosperity of a species is to be desired," it follows

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[1] *Animal Life and Intelligence*, p. 350.

"that, in order of obligation, the preservation of the species takes precedence of the preservation of the individual"; that the two cardinal and opposed principles of animal ethics must be observed; and there must be "sacrifices, partial or complete, of some of the individuals" for the good of the species. "Such are the laws, by conformity to which a species is maintained; and if we assume that the preservation of a particular species is a *desideratum,* there arises in it an obligation to conform to these laws, which we may call, according to the case in question, quasi-ethical or ethical."

Here facts are stated with accuracy; the laws of animal life are acknowledged which have applied in past ages; under their application the meliorist view of existence is rationally upheld. But throughout the whole account there is no "animal ethics"; there is no striving towards fit application of law; no regard to the good of the species; no reasoning but that of man; no ethical feeling save in the mind of the rational observer. In the animal there is no rationalising as to an order of obligation—no ought—no conscience—no responsibility for what has been done. In absence of all this, the fixed relations of animal life are stated, disclosing the system of things, thus making it possible for rational beings to recognise how the Deity, the First Cause, the Unsearchable, is ordering life for general advance toward a higher system of things.

This enquiry as to "animal intelligence" has led to these results:—*First,* that discriminating power manifested in all animal life is in accordance with the sensory apparatus possessed; *Second,* that the several species differ in discriminating power according as some one of the special senses has relatively greater prominence; *Third,* that performance of actions adapted to satisfy wants is provided for by co-ordination of nerves and cells within the brain, responsive to sensory impression; *Fourth,* that a lower type of mind, capable of perception and association, but incapable of reasoning or of moral discrimination, belongs to the higher vertebrates; *Fifth,* that animal intelligence has been developed only under influence of man, as animals have been trained to meet human requirements by means of associations established under rational guidance.

CHAPTER VIII.

PERSONAL EXPERIENCE AS CONNECTED WITH ACTION OF THE SENSORY SYSTEM.

LEAVING now behind us such uncertainties as may be allowed to hang over some phases of Animal Intelligence, and recognising that the highest degree of such intelligence belongs to man, we advance into the region of personal consciousness, taking first, our experience connected with functional activity of the sensory system. Here, we are in a region of certainty, familiar to all; and the problem now is to ascertain how the facts of nerve action are related with the facts of consciousness. It is admitted on all hands,—it could not be denied,—that there is a close relation between the action of nerve fibres, and an experience of our own, properly designated personal experience. How much is involved in this expression "personal experience" may afterwards appear; what is meanwhile to engage attention is the relation of two distinct sets of facts. When the hand is laid now on one surface and again on another, nerve sensibility is acted upon in each case, but besides this we are conscious of a series of sensations, enabling us to distinguish between a rough or smooth, a soft or hard surface. How far are such facts accounted for by the recognised functions of nerve and brain?

We have ascertained that a sensory apparatus is needful for this consciousness of sensation, that external excitation is the efficient condition for activity of the apparatus, and that the functions of the sensory nerve are fulfilled by continuance of molecular movement along the nerve line to the nerve centre. Further, in so far as sensori-motor action may have to be considered, we know that reflex action is accomplished in some cases through a lower centre, in other cases through a higher;

it is therefore needful to keep clearly before us the relation of the several central organs in the nerve system of man. To aid in this, the Diagram given by Dr. Ferrier is here introduced.

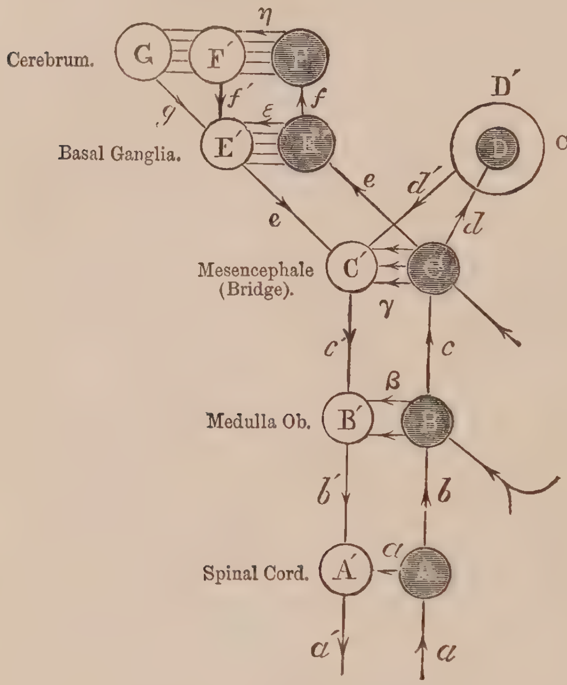

FIG. 47.—RELATIONS OF THE SEVERAL NERVE CENTRES IN THE HUMAN ORGANISM.

The dark circles represent sensory centres; the white, motor centres. The arrow shows the direction of the motion in case of functional activity. The letters read from below upwards, and the mark ′ above a letter thus, A′, indicates a motor centre in the spinal cord. G marks the frontal region (inhibitory). Cross lines, with Greek characters, mark provision for reflex action by "associating fibres," which increase in number as we ascend.

This diagrammatic representation shows clearly that centres are piled above each other; that sensory and motor divisions are in every case united; that every centre from the lowest to the highest is thus an organ of sensori-motor action;—a phase of activity which is correctly described as the grand characteristic of the system as a whole, and in all its sub-divisions. In accordance with this, we have advanced towards an explanation of animal intelligence, having recognised that such intelligence is dependent on co-ordination of the functional activity of the special senses.

It should be observed, however, that this diagram, while helpful in one way, becomes misleading in another way, by seeming to suggest a preponderance of motor over sensory activity, which does not exist; and by practically excluding from view, and tempting us to overlook, the highly important central apparatus appropriated to the special senses. Accordingly, if this diagram be allowed to do more than aid the imagination in representing the relations of distinct central bodies, it will favour an incomplete and distorted view of the scheme of the nerve system regarded as a whole. For, it will confirm the erroneous assumption that the system may be explained by reference to the nerve centres, while overlooking the important problem connected with diversity of sensory organs, bulbs, and tracts.

Recognising that man has a highly developed sensory apparatus for each one of the special senses, although he is surpassed in sensitiveness of organism in one direction or another by some of the animals, we have to inquire how far the nerve system supplies an explanation of human experience as connected with functional activity of sensory appliances.

That there are in human experience two distinct sets of facts, and that all that has hitherto been established concerning the action of the sensory apparatus explains only one of the sets, are the leading considerations for guidance of procedure now. The one set of facts, we may describe as the physiological; the other, as the facts of consciousness, which may apparently be described as non-physiological.

These two sets of facts are very closely connected, and yet are rigidly separate, being different in kind. They are so connected as to constitute a unity in life-action; and yet so distinct as to imply quite separate functions, the one of which cannot be fulfilled by the "organ" accomplishing the other. The facts of sensibility are provided for by sensory apparatus and brain, and often by apparatus not extending above the spinal marrow, or the medulla oblongata. The facts in human experience connected with action of sensory apparatus which extends into the cerebrum are found to imply a higher intelligence not included within "animal intelligence," and they are incapable of explanation without this admission. The one set of facts is included within the area of organism, there finding its completion; the second set seems to have its rise and continuance beyond this area, and has not its explanation in organism, but presents a distinct problem, for which we must find a solution. We cannot with certainty maintain that none of the animals has an experience analogous to ours, requiring a dual explanation; but that duality of action belongs to human life, will clearly appear as we proceed.

The separateness of the two sets of facts is illustrated so far, by the difference of the mode in which their reality is recognised by us. The distinction between scientific research directed on organisms not our own, and personal experience connected with the action of our own organism, is broadly marked and universally admitted. No one professes that knowledge of the action of sensory apparatus is obtained through personal experience; no one denies that man is conscious of the sensation dependent on contact of an object with the touch corpuscles. Experience does not involve knowledge of brain action. "Consciousness does not even tell us that we have a brain."[1] Nor have we any direct knowledge of what is involved in action of the nerve fibres. Only by the slow and laborious methods of anatomical and physiological research have we become aware of the physical conditions of sensory impression and motor activity. But the utmost advance of such research does not bring us within the region of consciousness. On the other hand, however carefully we study our consciousness, we do not thereby attain to any knowledge of the nerve system. This severance of the two departments of inquiry must impress all who study the relations of brain and mind. Professor Clifford assigned great value to the acknowledgment of this at the outset. "It is an exceedingly important thing . . . to notice how entirely separate these two classes of facts are" (*Seeing and Thinking*, p. 87). Again, "The first thing that we have to do is to realise as clearly as possible how profound the gulf is between the facts which we call Physical facts, and the facts which we call Mental facts"

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[1] Maudsley, *Physiology of Mind*, p. 21.

(*Lectures and Essays*, ii. p. 35). In like manner, Professor Huxley has said, "Whatever changes take place in the sensiferous apparatus are continuous with, and similar to, those which take place in the external world. But, with the sensorium, matter and motion come to an end; while phenomena of another order, or immaterial states of consciousness, make their appearance" (*Science and Culture*, p. 260).

The first condition for a successful study of the phases of human intelligence is a clear perception of the distinction between the two sets of facts. Contact with an external body produces an impression on our sensory system, exactly as it does in the case of the animals; but we interpret our sensory experience as the animals do not. There must, indeed, be considerable diversity of experience in animal life, on account of the diverse sensibility of apparatus, as for example in the case of the ant, the dog, and man in respect of smell. But in sensory experience, however great the diversity of degree in sensitiveness, the nerve structure and recognised laws of nerve action are the same for all animals, including man. We come upon a difference, however, by the introduction of a new set of facts, when we find sensory impressions interpreted, so as to make account of diversities of quality in external objects. If only we obtain a clear view of this difference between sensory impression and the interpretation of it, we secure our first position for contemplating human intelligence or understanding. We are sensitive, as the lower animals are; but we observe the qualities of objects, and compare objects by reference to their qualities, as animals do not. This difference between our sensibility and our knowledge of quality in objects, is that which we have to recognise and explain.

The suggestion that the two sets of facts present only two sides of the same thing, fails to meet the requirements. There is, indeed, a sense in which we may represent the two sets of facts as two sides of the same occurrence, inasmuch as we may accurately enough regard the two sets of facts as a unity in life-action. The ordinary observer would speak of the whole experience as a case of simple perception; but he would do so, only because he knows nothing of sensory apparatus, and does not attempt analytic procedure. The simplicity or singleness of the act, in his view, is accounted for by his omission of the physiological facts, excepting excitation by external contact with his organism. He magnifies interpretation, and ignores apparatus, testifying merely to the unity of consciousness, and thereby giving indirect testimony to the separateness of the functions of sensory apparatus.

That it is impossible to accept the representation of the unity of the facts, by granting that the two sets are only two sides of the same occurrence, will appear from consideration of each set of facts in turn. Inasmuch as all the special senses may be regarded as special modifications of touch, we shall adequately embrace all phases of sensory activity by concentrating on touch, whether at the tips of the fingers, or over the entire bodily surface.

Taking first *the action of sensory apparatus*, it does not include the action of intelligence. Functional activity of a sensory nerve does not embrace interpretation of what occurs. The action begins at the periphery, and ends in the sensory cell in the cerebrum, or, more definitely, in the "sensorium;" the functions of the sensory nerve are fulfilled in the rise of molecular motion at the periphery, and the close of it in the cell,—in the excitation of a touch corpuscle, and in the impulse to a sensory cell or set of such cells. Interpretation of the peripheral impression is not a continuance of molecular motion. Any continuance or extension of this motion would result in reflex action, illustrated by the passing of the molecular motion through the sensory cell to a motor cell, thence to a motor nerve, thence to a muscle. Interpretation is, indeed, connected in time with reception of impulse at the sensory nerve cell, but it is concerned in point of fact with occurrence at the periphery, and even with that which is external to organism, occasioning excitation. So far from the molecular motion in the sensory apparatus explaining what occurs in the interpretation of its own activity, it is clear that if interpretation could be represented to the imagination as a form of motion, its direction would be *towards the periphery*, and sensory apparatus could not afford any explanation of such motion.

Taking next *the action of intelligence in sensation*, it does not include the action of sensory apparatus. Admitting that an external object occasions peripheral excitation, and that the impulse to the sensory cell gives rise to the experience in consciousness which we name sensation; we do not know these facts as matters of experience, they are not included within our consciousness. That which we *know* as a part of present experience, and which we classify as belonging to the multifarious knowledge given in consciousness, is a feeling or sensation, and a perception of quality in an external object. We experience a given feeling, which we call a sensation, and which is a distinct fact in personal experience, belonging to ourselves and to no other person. By the aid of intelligence, combining past with present experience, we are able to localise the affection of our organism as occurring at the tips of the fingers, while we are unable to identify molecular movement up the nerve fibre, or in the sensory cell. Further, in consequence of intelligent comparison of past experience,—never without this,—we are able to distinguish qualities in objects, speaking of separate surfaces as smooth or rough, hard or soft. And these qualities, smoothness, roughness, and the others, have no resemblance with our feelings, but are recognised by us as things quite different. Thus it is that, taking our feelings as testimony concerning the objects affecting our sensibilities, we, by exercise of intelligence, reach a definite knowledge of the external world. The action of the sensory apparatus is needful in order to have sensation and to gather the knowledge of the external world thereby obtained; but it is altogether insufficient to account for the knowledge itself, that depending upon a power to interpret our sensations, for which organism makes no provision. The chicken can see more exactly than we can, and is able more rapidly to satisfy its hunger by aid of sight than we are; but this illustrates nothing as to the exercise of intelligence, so little is sensory action capable of being identified with intelligence, or being regarded as a part of the same movement which afterwards appears in the form of intelligence. Suppose for the moment that we may speak of the external object as the "cause" of our sensation, as contact with it is the essential condition of the whole activity involved, then we must agree with Professor Huxley in saying, "that no similarity exists nor indeed is conceivable, between the cause of the sensation and the sensation. Attend as closely to the sensations of muskiness, or any other odour, as we will, no trace of extension, resistance, or motion is discernible in them. They have no attribute in common with those which we ascribe to matter; they are in the strictest sense of the words immaterial entities" (*Science and Culture*, p. 258).

Thus it appears impossible to represent the two sets of facts as only two sides of the same thing; and unwarrantable to describe the phenomena of consciousness in language applicable to material existence. The phenomena of nerve action and the phenomena of consciousness do occur together, constituting together a simple phase of activity in human life; but they are so distinct in nature, and they so clearly depend on different powers, that the one set includes successive movements of the organism, the other involves an interpretation of these movements or of their beginning by reference to qualities in objects distinct from our organism. Thus our sensibilities and our thoughts differ essentially. Nerve apparatus is first acted upon from without, and it next acts in accordance with its own laws by propagation of movement; for the sensory and motor sides of the apparatus are so related that movement on the one side may pass through to the other; but these occurrences mark the limits of action belonging to the nerve system. Nerve apparatus, when stirred by external excitation, is self-acting and self-adjusting, but not self-interpreting.

As, then, we are in search of an accurate account of the causes of distinct occurrences, it seems necessary to remark that our thoughts are not caused as our sensibilities are, that is, contact of the touch corpuscle with an external object, which causes nerve excitation, does not cause our consciousness, with the sensation and thought which it includes, although consciousness, sensation, and thought are all concerned with what occurs in organism. This is equally clear whether we consider excito-motor action in the nerve system, or action in consciousness. We may, speaking roughly, say that the external object causes our sensation,—and popular language will commonly take this form,—but the simplest analysis suffices to show that we are at fault in saying so. Neurology here comes to the support of the old psychology, which neurologists under influence of their first discoveries had begun to deride. Because the old psychology did not know, as the old physiology did not, the facts which persistent investigation into nerve structure and function has brought to light, it was too hastily supposed that the old psychology was at fault in its conclusions. But more patient study has shown that neurology by its newest discoveries bears testimony for the old psychology, showing that sensory apparatus cannot account for the facts occurring within consciousness. The two sets of facts imply two distinct orders of causation.

The testimony of neurology is explicit in support of the conclusion that the known functions of the nerve system uniformly imply simple action of apparatus, and do not include interpretation of the sensory affection. Comparison of functional activity as connected with lower and higher centres, affords the first line of evidence. The laws of sensory action are uniform in all phases of animal life, and in all divisions of the nerve apparatus within a single organism. Taking the latter as sufficient here, sensory apparatus connected with the spinal cord or medulla oblongata, fulfils the same functions as the sensory apparatus which has its central terminus in the cerebrum. Looking at the whole nerve centres in man, from below upwards, as suggested by the Diagram, fig. 47, p. 290, we interpret according to the analogies of the system as a whole, if we conclude that functional activity is carried through and completed in the more extended apparatus, just as it is in the more restricted range having its central organ somewhat lower down. Physiology does not discover any new function in the higher part of the system, except more detailed co-ordination. Thus far, therefore, its testimony to the uniformity of action favours the conclusion that sensory apparatus does not account for the facts of consciousness.

Again, the organs of special sense are closely allied with the cerebral region, and co-ordination of the apparatus of these senses by nerve cells and nerve lines within the cerebrum, yields additional testimony in support of the view here maintained. The special senses present only modifications of sensory apparatus, in accordance with which sensibility to the action of light, sound, odour, and taste, is secured. As molecular action takes place in each case, it is in harmony with the laws of sensory activity that we suppose some variety in the form of motion in each case, affecting possibly the rate of motion. This may differentiate the action of distinct sensory apparatus, but it contributes nothing towards explaining the second set of facts, including sensation, comparison, and inference. We may, therefore, grant a modification in the rate of that molecular movement which is common to all sensory apparatus; but this leaves untouched the problem of interpretation of sensory impression as accomplished in rational life.

Reference to the facts of co-ordination of distinct centres in the cerebrum, also bears witness to the difference of kind marking the facts of consciousness. For co-ordination of centres is shown by neurology to be a matter of mechanical contrivance, merely involving within the brain a continuance of the arrangements and laws of action already recognised as essential in lower nerve centres.

On the side of apparatus there remains only, as a last resort, the suggestion that some diversity in the nerve cells found within the cerebrum, may warrant a conclusion in favour of higher functions being performed within this organ than within lower nerve centres. On the opposite page, fig. 48, is given a drawing, illustrating the relative appearance and size of the nerve cells in the five different layers of the human brain, taking the ascending frontal convolution as affording the typical representation. The figure is slightly reduced in size from a drawing submitted to the Royal Society of London, by Drs. Bevan Lewis and Henry Clarke, with a paper on "The Cortical Lamination of the Motor Area of the Brain," and communicated by Dr. Ferrier, in January 1878 (*Proceedings of the Royal Society*, vol. xxvii. p. 38).

The cells vary greatly in size, and to the largest of them in the fourth layer Betz has given the name of "giant pyramids." Attracted by the presence of such cells, Haeckel has ventured the suggestion that they fulfil "psychical functions," and he has accordingly named them "mind cells" (*Evolution of Man*, vol. i. p. 129, transl.) His own statements in propounding this hypothesis awaken misgivings as to its value. Thus he tells us that this "large-branched nerve cell or mind cell" is "a highly complex apparatus, the more

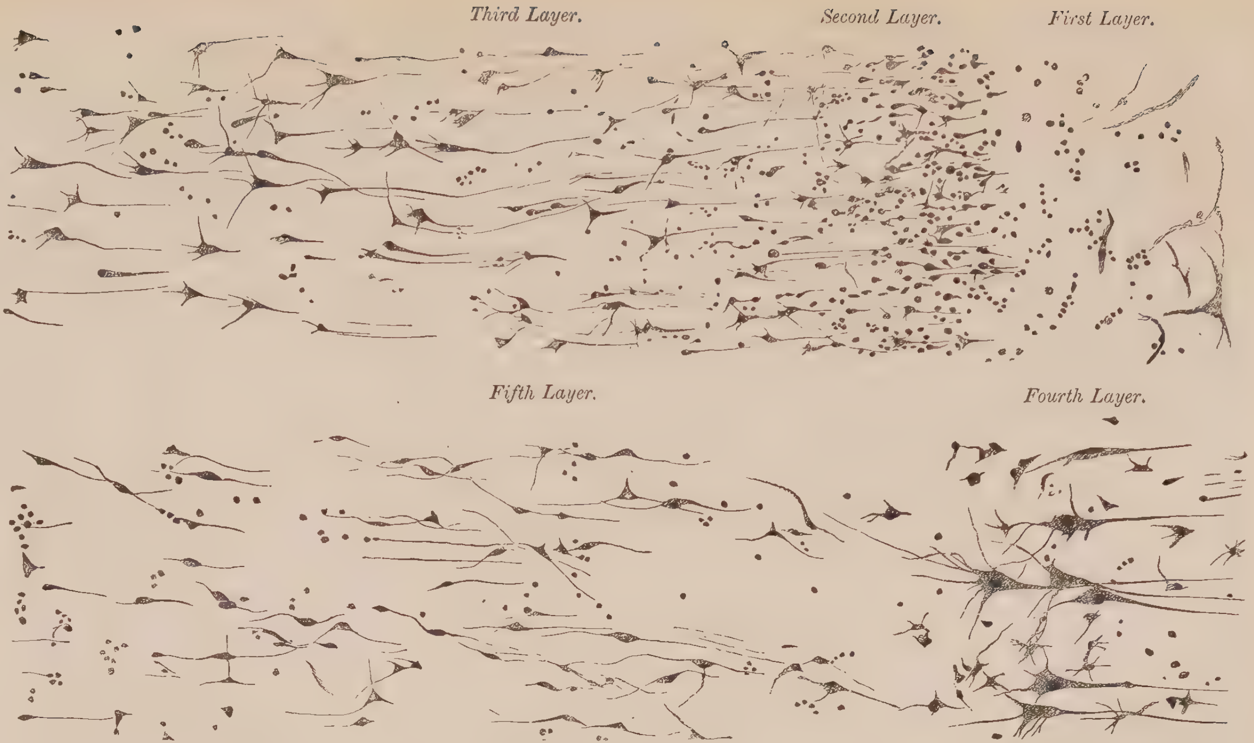

FIG. 48.—APPEARANCE OF THE CELLS IN THE FIVE LAYERS OF THE HUMAN BRAIN IN THE ASCENDING FRONTAL CONVOLUTION. (From drawing by Lewis and Clarke.)

minute structure of which we have hardly begun to know, even with the help of our strongest microscope, and the significance of which we rather guess than know." Yet with this confession of ignorance, Haeckel immediately, in the next sentence, declares dogmatically that "its complex mechanism is capable of the most intricate psychical functions." Two such declarations standing in juxtaposition seriously discredit the scientific worth of what is propounded.

In glancing down the figure from the first to the fifth layer of the cortex, it is at once apparent that, in accordance with the five laminated arrangement described by Meynert, the cells in the different layers vary greatly in number and size. They are comparatively few and small in the first layer; they are most numerous, but still small in size in the second layer; their size increases, and their number diminishes in the third layer; by far the largest cells are grouped within the fourth layer; and again the cells diminish in size towards the base. Concentrating attention on the fourth layer, we have to inquire what conclusions as to the functions of the cells much larger in size than those lying both above and below, seem warranted by the evidence at command.

Looking from above downwards there is a steady increase in size until the central portion of the cortex is reached, and again there appears a diminution in size immediately underneath. The characteristics of the several layers as indicated by Drs. Lewis and Clarke in the paper which the figure illustrates, may be briefly indicated. In the *first* layer, there is on the surface "a pale narrow band," in which the tissues are "connective, nervous, and vascular," and just below this are cells, larger and smaller, from $6\,\mu$ to $13\,\mu$.[1] The *second* layer "consists of a series of closely aggregated pyramidal and oval cells of small size, with apical processes radiating towards the surface of the cortex," and numerous other processes arising from the basal angles. "With the exception of their pigmy size and extremely crowded aggregation, no differences are apparent between them and the larger elements of the third layer." These cells vary in length from $11\,\mu$ to $23\,\mu$. In the

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[1] μ represents a micro-millimètre, which is $\frac{1}{1000}$th part of a millimètre, which equals the $\frac{1}{1000}$th part of a mètre.

third layer, "the cells almost uniformly increase in size from above downwards." They vary in length from 12 μ to 41 μ, and small pyramidal bodies are found low down in the layer alongside the larger. "Their apical process is directed radially to the surface of the cortex, and can be traced into its second layer." The basal processes pass off in an oblique direction towards "the radiating fibres of the medulla." In the *fourth* layer a stratum of angular cells is "intersected by a layer of immense ganglionic cells." These ganglionic cells "differ very materially from any of the elements already described. The enormous dimensions to which they attain, averaging 71 μ in length by 35 μ in breadth, stamp them as the most notable objects in the whole depth of the cortex, whilst in special cells the not unusual length of 126 μ shows that they occasionally rival even the large multipolar cells in the anterior column of the cord." These are the cells which Betz named the "giant pyramids," and which, he concludes, fulfil the functions of motor cells. Lewis and Clarke give the following results of their observations. These cells vary in form. "The pyramidal form is frequent;" "the protoplasmic contents extend for some distance into the very numerous branches" arising from the cell. The average number of processes or fibres passing off from ninety of these cells, exclusive of the two main processes, the one at the apex and the other at the base, "was seven; the largest number observed was fifteen." "These giant cells are distributed over certain *definite areas* which are remarkably constant, and it appears to the authors that these *cell groupings* are especially and exclusively a characteristic feature of the motor area, as defined by Ferrier." Giant cells "may be found in isolated positions" in other parts, but not in large groups or distinct areas. The *fifth* layer consists largely of spindle-shaped cells, with some intermixture of pyramidal cells. The average length here is from 25 μ to 32 μ.

With this summary we are ready for the question, Can the second set of facts discovered in consciousness be accounted for by reference to the giant cells? Or, otherwise expressed, Can giant cells be isolated from other nerve cells, so as to assign to them "psychical functions," or to warrant us in classifying them as "mind cells," in contrast with sensory cells, on the one hand, and with motor cells, on the other?

That they are the most prominent cells in the whole cortex is clear, and according to the functions assigned to them will be our judgment of the largest demand made on the nerve energy of the organ. 1. The cerebrum is the chief organ of sensori-motor activity, and from this fundamental position interpretation of the functions of its cells must proceed. 2. In accordance with this, our inquiry must first turn on the question whether the giant cells are connected with sensory or with motor fibres. 3. In absence of direct evidence, the indirect testimony is adverse to the view that the giant cells are in relation with the sensory apparatus, and this must be accounted unfavourable to the hypothesis which would connect them with interpretation of sensory impressions. 4. The structure of the giant cell shows that its size is essentially connected with multiplication of processes, or nerve-fibres issuing from the cell; and these most naturally suggest co-ordination of movements passing through the cell, providing for inter-relations between proximate centres. 5. The giant cells are prominently grouped together in a region of the cerebrum identified as a leading motor centre, a fact which harmonises with the previous statement, and points to motor activity as their leading function. 6. Giant cells are found, not merely in the brain but in the spinal cord and in the sympathetic system; therefore it is impossible to interpret their activity as if they were exclusively cerebral in location, and could be regarded as "mind cells," fulfilling the functions of a higher intelligence. 7. Giant cells are found in the brain of greatly inferior animals, a fact adverse to the hypothesis that they are "mind cells." The illustration of the giant cell given on p. 128, vol. i. of Professor Haeckel's *Evolution of Man*, is that of a cell magnified 600 times, and is stated to be "a large branched nerve cell or 'mind cell' from the brain of an electric fish (torpedo)," an animal which does not stand high in brain structure. All these considerations present a cumulative body of evidence adverse to the hypothesis that human intelligence can be attributed to the giant pyramidal cells abounding in the fourth layer of the brain. All available evidence favours the conclusion that these giant cells are motor cells largely concerned in the functions of co-ordination of related intra-cerebral movements. It thus seems warrantable to infer that such co-ordinated movement takes rank as the highest function of brain. In accordance with this view is Dr. Ferrier's conclusion as to the frontal regions in the human brain, based on the whole range of experiments under electro-excitation,—that they are "inhibitory-motor centres" (*Functions of the Brain*, p. 287), such as may be associated with an exercise of attention.

We have now before us a distinct set of facts unexplained by neurology, for the phenomena of consciousness are not included among the facts of nerve-action. The two sets of facts are closely associated, but they are not two sides of the same thing; nor are the facts of consciousness a continuation of the facts of the sensory apparatus, but an order of fact quite different; nor is a parallelism between the two sets of facts maintained, for the facts of consciousness are extended quite beyond the range of sensory action, and are concerned with the qualities of external objects of which the action of the sensory apparatus makes no account.

A single sensation, such as that occasioned by touching a sheet of note-paper, is a distinct experience. It is so far accounted for by what physiology teaches, but it is explained thus only in part. Sensibility at the tip of the finger, conductivity along the nerve fibre, and receptivity or consequent molecular action in the nerve cell, are facts affording exact and important information, but they leave the explanation incomplete. Consequent on each distinct act of the nerve fibre some molecular change takes place, which may be represented as a movement, or shock within the sensory cell. This, however, does not help towards a philosophy of sensation, for it is admitted that molecular change in like manner occurs in the motor cell, for a common law of brain activity applies equally whether the action be sensory or motor. This being so, the admission of molecular change in the sensory cell as the result of the activity of a sensory nerve, gives no help towards the explanation of sensation.

We need, then, to account for the simplest element in human knowledge—*Sensation.* In touching a piece of paper we are conscious of a distinct experience, little more than momentary. We know this experience as our own, and report it as a distinct fact, rather than a continuous state. I know myself as experiencing a sensation consequent on the single act of tactile impression. What Physiology has done is to account for tactile impression by sensibility belonging to our organism, as to all organism. What Physiology leaves unexplained is knowledge of Self as existing in this particular state; which is for an intelligent being the most simple phase of experience. Psychology begins with this as its primary fact.

Next, we take account of *a succession of sensations*, forming a continuity of experience. Here we advance a step by observing that our experience past and present has included a variety of sensations. The particular sensation arising at a given moment is known as distinct from another previously experienced. There is thus consciousness of succession in respect of time, the one sensation coming after the other. This succession, involving not only variety but combination or unity of conscious existence, is within our experience. The laws of nerve action provide for successive acts of the sensory apparatus, but they do not provide for the sustaining of molecular action in the fibre and cell, much less for the comparison of consecutive impressions through means of these. A nerve fibre and nerve cell must be clear of one impression before they can be made vehicles of another. *Singleness of action is the law of exercise for the sensory nerve.* Successive touches of the note-paper, table-cloth, and ink-bottle give successive molecular movements; combination of all three impressions or comparison of them is beyond the reach of sensory apparatus. Under nerve conditions, separateness of result is essential; only under intellectual conditions can unity be attained. Even if the hypothesis were ventured that there may be in the sensory cell a *register* of the shock delivered there, this would not help towards an explanation of the facts. For if there were such a register, and the registration were made on a sensitive surface, and were permanent, the requirements of the case would not be met. A register contains materials for comparison, does not institute comparisons.

Facts here carry us quite beyond mechanical and chemical action in the nerve system.

Comparison of separate sensations in consciousness implies an exercise of intelligence superior to sensation. Sensation and consciousness are not identical; consciousness has the particular sensation as its object, and involves a wider and higher exercise of intelligence; for while sensation is only a particular and single experience, in accordance with the singleness of nerve action on which it depends, consciousness distinguishes one sensation from another, recognising not only that one sensation is separate from another in the order of time, but that they differ from each other in character.[1]

Sensation implies a sensory impression, and every new sensation a new impression; but comparison of sensations implies knowledge of a sensation which has passed away, knowledge of another which still exists, and intelligent discrimination between the two. This intellectual action may be illustrated without introducing succession in time. If at the same moment we use two fingers, rubbing the tip of one on the leather of the desk, and the tip of the other on the polished wood, two distinct impressions are made, two distinct sensations are experienced at the same time, but each fibre does its own work quite apart, and each sensation is a perfectly distinct event. The separateness of these two sensations is the simple result of the distinction of the nerve fibres, but the comparison of the two is an exercise for which while nerve fibres make provision, they cannot themselves accomplish. But, if the whole ten fingers be moved over the same surface at the same moment, we fail to distinguish ten distinct sensations. The failure in discrimination does not occur because there are not ten distinct impressions, with ten distinct molecular changes in the brain, but because we have not discriminating power enough to deal with so many. Hence it happens that multitudes of impressions are made on the sensory nerves which are never noticed, thus confirming the view that our power of comparison is quite distinct from that which determines the existence of the sensation. Our nerve fibres can do more work than our intelligence can observe.

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[1] Mr. James Mill, Mr. J. S. Mill, and Professor Bain have all favoured the view that sensation and consciousness are not distinct, or at least are not uniformly and of necessity distinguished by us. The untenableness of such a position is apparent if we grant that consciousness includes distinction of sensations, and makes account of their relations. I have elsewhere discussed this question at length, *Handbook of Moral Philosophy*, pp. 100-108.

Mental power is further illustrated by the fact that *we interpret our sensations so as to distinguish the surfaces brought into contact with our sensory system.* When we compare the smooth surface of the paper with the rougher surface of the table-cloth; and, again, when we distinguish between the smoothness of paper and the smoothness of glass, a new and higher exercise of intelligence is introduced. We advance from Sensation, to what we more properly designate *Perception.* By aid of auxiliary physical appliances, which may include several of the special senses, we attain to knowledge of qualities in objects. The nerve system is not sufficient to explain this exercise, and we have seen that there is no evidence that animals are capable of it. Sensations provide materials from which we gather our knowledge, but neither the sensations themselves, nor the impressions by which they are originated, can account for our knowledge. Here comparison and memory both have enlarged exercise, while voluntary use of several instruments of knowledge affords enlarged illustration of an intelligent nature at work for intelligent ends.

A sensation from a rough surface does not perform work in comparing itself with a sensation from a smoother surface. A sensation from a smooth hard surface does not compare itself with that from a rough soft surface. Mr. J. S. Mill favours the theory which regards Mind as a series of feelings, yet he has clearly shown its insufficiency. He says, "If, therefore, we speak of the mind as a series of feelings, we are obliged to complete the statement by calling it a series of feelings which is aware of itself as past and future" [present?]; "and we are reduced to the alternative of believing that the mind, or ego, is something different from any series of feelings, or possibilities of them, or of accepting the paradox, that something which *ex hypothesi* is but a series of feelings can be aware of itself as a series."[1] The alternative "that the mind, or ego, is something different from any series of feelings, or possibilities of them," is tenable. The intelligence which distinguishes sensations, and discriminates objects coming into contact with the organism, is so different from sensation itself, that it contemplates a past sensation, and compares it with the present. And when this sensation has given place to a third, intelligence renews the exercise of discrimination, extending its range by including all three sensations. The alternative of a distinct intelligence is a tenable theory, consistent with the facts. The other alternative, that the mind is "but a series of feelings," "aware of itself as a series," is untenable, involving a violation of the fundamental principles of neurology.

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[1] *Examination of Hamilton's Philosophy*, p. 242.

On the evidence now adduced, we reach the conclusion that the Intelligence of Man, as known in personal consciousness, is of a nature entirely distinct from sensory apparatus, its functions being incapable of explanation in accordance with the laws of sensory activity. Mind is not a product of cerebral evolution, and could not be so, inasmuch as even its lowest function is incapable of being performed by sensory apparatus.

The facts of neurology described in detail in the earlier portion of the present treatise, lead to a double conclusion: 1. That the whole nerve-system, including sensory and motor apparatus, with its complex arrangements of nerve-centres, is concerned with sensory and motor activity, and co-ordination of the multifarious related movements needful in accordance with the unity of the organism; 2. That the nerve-system as described is incapable, either as a unity, or by any of its parts, of accomplishing the functions detailed in the foregoing analysis of consciousness.

The facts of consciousness, now briefly enumerated, lead to the conclusion that Mind is a distinct order of existence, different in nature from the nerve system, differing in the mode of its action from the mechanical action of sensory apparatus, and capable of interpreting the sensibilities of our organism, so as thereby to discover a rational order in things external, or adaptation of related things in nature to a rational purpose. In accordance with the powers thus ascribed to Mind, men in all ages have found it possible, with more or less accuracy of detail in proportion to the range of their acquaintance with facts, to reach some interpretation or theory of natural occurrences. "They have felt that out of the things that they studied something like a similar intelligence was looking at them" (*Seeing and Thinking*, by Professor Clifford, p. 111).

It now remains that some statement be given of the organic and non-organic elements in the unity of life-action, involving cerebral and mental activity. This may be accomplished within brief space, after the preceding investigations.

ORGANIC ELEMENTS INVOLVED IN SENSORY EXPERIENCE. 1. The organic structure is represented by the touch corpuscle, nerve fibre, and nerve cell. 2. The organic function is represented by molecular motion started at the corpuscle, and continued to the cell. 3. The laws of organic progress or evolution already indicated: (*a.*) repeated use gives increased facility; (*b.*) this leads to established susceptibility; (*c.*) such susceptibility is capable of hereditary transmission.

NON-ORGANIC ELEMENTS CONNECTED WITH SENSORY EXPERIENCE. These will be best presented in threefold form. 1. Interpretation of impressions made on the sensory apparatus. An impression passes off in motion of the fibre and cell, but it is interpreted or understood so as to connect our experience with its cause. This exercise of intelligence prepares the way for localising of impressions, and for acquiring knowledge of external objects by aid of the impressions on our organism. 2. Inference, by comparison of past experience with present. Each sensory impression is but a momentary occurrence. Impressions follow each other in rapid succession, one giving place to another. Within the organism itself it is possible to induce familiarity with recurring impression, and susceptibility to its renewal. But beyond all this, intelligence institutes comparisons of the present experience with past experiences, detecting similarity and differences, thereby providing for classification of objects as like or unlike, as belonging to the same or to different species. 3. Synthesis of knowledge, by use of forms and materials belonging to the mind itself, in process of which each individual mind builds up for itself a representation of the system of things in the midst of which we exist. The mind thus proceeds not only to deal with varieties in its own sensory impressions as they pass, but, in the exercise of thought, it goes out upon the world, and by reference to quantity, quality, and relation, forms its conceptions of things and of their harmony. This synthesis of knowledge is not unconnected with sensory impressions—it is largely dependent upon them; but it is nevertheless far removed from them, involving forms of rational procedure, without which sensibility would occasion merely a fleeting succession of shocks in the nerve centre. Only by using the forms which intelligence itself supplies, and which are the prerequisites for rational procedure, can synthesis of knowledge prove possible.

These three forms of intellectual action, interpretation of impression, inference, and synthesis of knowledge, as now described in a brief and summary way, represent the nature and functions of Mind. They indicate the presence in human life of an Intelligent Nature, distinct from organism, as it is different from that which we designate "Animal Intelligence."

Objections against this representation, taken on physiological grounds, are destitute of logical value. The conclusion that mind is not the product of cerebral evolution is antagonistic to the view which seeks to include human intelligence under a doctrine of continuity in the evolution of animate existence, and opposition from this direction must be expected. Professor Huxley states his objection in the following terms:—"The doctrine of continuity is too well established for it to be permissible to me to suppose that any complex natural phenomenon comes into existence suddenly, and without being preceded by simpler modifications; and very strong arguments would be needed to prove that such complex phenomena, as those of consciousness, first make their appearance in man" (*Science and Culture*, p. 232). The evidence for continuity in the evolution of organism, whatever be its value as bearing on a hypothesis inclusive of all animate existence, is sufficient to establish evolution in certain clearly recognised species. This admission favours a wider application of the doctrine, and gives warrant for the claim that strong evidence must be presented for its restriction. Such evidence has, I think, been supplied in the foregoing statements. It is clear, for example, under the known laws of organic evolution, that a pouter pigeon may be obtained from the wild pigeon, and that a pointer dog may be obtained from an ordinary breed of dogs; but such facts in the history of evolution of organism have no real value, either direct or hypothetical, in support of evolution of human intelligence through evolution of organism. What we require is evidence for extension of the theory of continuity to the higher intelligence; and what is here maintained is that there is no such evidence, and that evidence to the contrary is abundant. It is natural, from the standpoint of evolution, to suggest that higher forms and functions must be "preceded by simpler modifications." But there are no simpler modifications of interpretation of sensory experience than consciousness of sensation. There is molecular action of nerve apparatus, and there is consciousness of sensation; but there is, and can be, nothing between. Evidence shows that animals do not interpret, and that men do; and no accumulation of data as to evolution of organism can bridge the chasm here existing.

Accordingly, it is vain to appeal as Professor Huxley does to the "law of parcimony." This law is that substances or causes are not to be multiplied needlessly; but conversely, they are to be multiplied according to need; and need for a duality of causes arises when phenomena to be explained differ in nature. The essential difference between molecular motion in a nerve cell, and interpretation of an occurrence at the periphery, is the first and simplest evidence for distinguishing the causality of organism, and the causality belonging to Mind. Professor Huxley, when referring to the rival theories, seems therefore unfortunate in his reasoning when he says, "If I must choose among them, I take 'the law of parcimony' for my guide, and select the simplest, namely, that the sensation is the direct effect of the mode of motion of the sensorium. It may justly be said that this is not the slightest explanation of sensation; but then am I really any wiser, if I say that a sensation is an activity (of which I know nothing) of a substance of mind (of which also I know nothing)?" (*Science and Culture*, 263.) We certainly should not be wiser by venturing an affirmation as to a thing of which we know nothing. But it is impossible to say that we know nothing of sensation, when a sensation is matter of personal experience, whereas "the mode of motion of the sensorium" is not.

Further, it is impossible to maintain his position consistently with the following statements, that sensations "have no attributes in common with those we ascribe to matter; they are in the strictest sense of the words immaterial entities" (258): and that "the most elementary study of sensation justifies Descartes' position, that we know more of mind than we do of body; that the immaterial world is a firmer reality than the material" (259).

The completeness of the contrast between organic and non-organic functions involved in our sensory experience will appear by reference to the various aspects of *causality* disclosed by analysis of the phenomena. In one view, the *external object* coming into contact with the touch corpuscle is the original cause of the sensory impression, for contact with the external is the occasion of the activity within the sensory system. The occurrence involves a particular direction of molecular motion resulting in a shock or impulse to a sensory cell or to a number of such cells. The cause is mechanical, and so also is the result. In another aspect, the *nerve energy* in the brain is the cause of the occurrence, for upon supply of such energy, vitalising the whole apparatus, from corpuscle up to the sensory cell, depends the possibility of the sensory activity which is consequent upon contact with material existence distinct from our organism. Without excitability of the touch corpuscle, conductivity of the nerve fibre, and receptivity of the sensory cell, there could be no impression on our organism such as is made. Without this, organism would be insensate as wood or stone. Contact is the occasion, sensibility is the condition, of functional action within the sensory system. But causality as concerned with interpretation of what occurs at the periphery where the touch corpuscle is lodged, is entirely different from causality in these two cases, inasmuch as it is not possible to represent such interpretation as a continuance of the molecular motion within the nerve cells,—or as an extension of the mechanical action occasioned by contact of the external object with a sensitive organism. The causality now appearing is essentially different, as the form of action differs entirely from the functional activity of the nerve system. Intelligent action, as it is *reflective*, stands in contrast with sensory, and also with sensori-motor activity; as it is a turning of *observation* on occurrence at the periphery, it is essentially different from the occurrence observed; and as it is an *understanding* of the occurrence by reference to contact of an object with our organism, it requires a cause differing both from the object and from the sensibility of the organism itself. Thus the causation of intelligent action is different from causation of motion and its propagation,—the evidence for both making it needful that we distinguish between Organism and Intelligence,—between Brain and Mind.

Ample illustration of this difference can be given by contrasting the multifarious sensory impressions, with the proportion of them interpreted by us. Sight may be taken as affording examples. The whole of the objects within range of our vision, as we stand at a given point, or move along a road, make an impression on the retina; continually changing photographs arise on its sensitive surface. With this action of light on the net-work of delicate nerve fibre, there is continually in progress some molecular movement from the retina to the brain. But not a tithe of the impressions so made on the "sensorium" are interpreted by us. Things are seen but are not observed and considered. There is in many instances no reflection upon the sensory impressions, though there is no ground for doubting that the action of the nerve system is the same in all cases of visual impression. As Professor Clifford has said, "The beginning of the physical train consists of light going into the eye, and exciting the retina, and then of that wave of excitation being carried along the optic nerve to the ganglion. For all we know, and it is a very probable thing, the mental fact begins here at the ganglion. There is no sensation till the message has got to the optic ganglion, for this reason, that if you press the optic nerve behind the eye you can produce the sensation of light. It is like tapping a telegraph, and sending a message which has not come from the station from which it ought to have come; nobody at the other end can tell whether it has come from that station or not. The optic ganglion cannot tell whether this message that comes along the nerve has come from the eye or is the result of a tapping of the telegraph, whether it is produced by light or by pressure upon the nerve" (*Lectures and Essays*, by Professor Clifford, i. p. 51). This statement shows very convincingly how incapable the optic ganglion is of interpreting the impressions received. But though "the ganglion cannot tell," intelligence can readily discover, by a process of experiment, whether the sensation arises from a state of the organism, or from the action of light entering the eyeball. We refuse to allow ourselves to be disturbed by optic illusions when detected by experiment. Such experiment illustrates the action of Mind,—the interposition of a quite different power, operating according to laws distinct from those applying within the sphere of molecular motion.

A statement of general conclusions as to the relations of Mind and Brain can now be made with clearness and certainty. Brain is not the organ of Mind in the sense in which it is the organ of sensori-motor activity. It is the latter inasmuch as it supplies nerve energy, providing for the vitalised condition of the whole nerve apparatus, both sensory and motor, and affording, by its position and structure, the highest centre for sensory receptivity, for inter-communication between correlated points, for government of the system as a whole, and for motor activity. But in these things we reach the limits of its functions. There is no evidence to support the position that "mind" is a function of nerve fibres and nerve cells. The second set of facts have, as Professor Huxley says, "no resemblance" to the other; as Professor Clifford has said, they are "entirely separate." Professor Huxley has illustrated the difference by observations as to the sense of smell, taking a musky smell as the example. "Attend as closely to the sensation of muskiness, or any other odour, as we will, no trace of extension, resistance, or motion is discernible in them. They have no attribute in common with those which we ascribe to matter; they are in the strictest sense of the word immaterial" (*Science and Culture*, p. 258). Accordingly, we conclude that mind is an immaterial power, capable at once of guarding its own interpretation against risks arising from illusions of the senses, and of reaching accurate knowledge of the external world by means of the senses. Brain is the organ of Mind, in this sense, that it is by means of the varying movements within its sensory centres that mind reaches an understanding of the nature of external objects. But it is impossible for us to observe the action of mind by making the transition from molecular action in the nerve cell into consciousness. Only in consciousness do we know the phases of intellectual activity. Equally impossible is it to regard our intellectual acts as if they were directly cognisant of the activity of nerve cells, for our understanding concerns itself rather with qualities of objects as these may be ascertained by means of impressions on our organism.

When, then, the two sets of facts—with two spheres of activity—the one belonging to Brain, the other to Mind, are contemplated, it becomes clear that we cannot connect them by tracing a line of transition out of the material into the mental sphere. We cannot pass from the one to the other. As Professor Tyndall has said, "The passage from the physics of the brain to the corresponding facts of consciousness is unthinkable. Granted that a definite thought and a definite molecular action in the brain occur simultaneously, we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable us to pass, by a process of reasoning, from the one to the other. They appear together, but we do not know why. Were our minds and senses so expanded, strengthened, and illuminated as to enable us to see and feel the very molecules of the brain; were we capable of following all their motions, all their groupings, all their electric discharges, if such there be; and were we intimately acquainted with the corresponding states of thought and feeling, we should be as far as ever from the solution of the problem, How are these physical processes connected with the facts of consciousness?"[1] But the relation between Mind and Brain is constant, and we know of no means by which a knowledge of the outer world is attainable, save through the agency of a sensitive nerve system. We clearly recognise that the actual knowledge thereby acquired must vary according to the character and quality of the nerve system, so that certain animals may have a more extended acquaintance with some forms of existence than we can have; but we are assured, beyond risk of doubt, that objects possess qualities such as we attribute to them. That there can be no other method of ascertaining these qualities of material objects, it is impossible for us to maintain; but this is certain, that the sensibility of our nerve system is sufficient to guide to a large acquaintance with the external world.

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[1] *Fragments of Science*, p. 121.

At the same time, it is impossible to construct a theory of the manner in which Mind maintains its relations with the nerve system. The suggestion of a "clavier theory," in accordance with which the mind is regarded as playing on brain as on a musical instrument, is inadmissible. Restricting attention here to the sensory apparatus, it must be obvious that the analogy is inappropriate and misleading. Through the sensory system the mind receives, according to fixed laws, impressions coming from an outer world. All these it is capable of interpreting. The communicating lines may act according to normal conditions, or, to use Professor Clifford's analogy, they may be tapped at points not ordinarily operated upon, but mind can detect and interpret in either case. The possibilities of our life are vastly higher than those attainable by the functions of organism, and a somatic scheme falls greatly below its most ordinary characteristics. But mind, in performing its functions, must depend upon facts communicated through sensory apparatus. In what way this communication passes from one to another is, and must remain, a mystery. Assuredly, Mind does not play on the sensory system so as to produce the results of its functional activity; but Mind can interpret the harmony of what is impressed on sensory centres in the brain. So far as the sensory apparatus is concerned, it is clear in what sense Brain is the organ of Mind. It is so, in presenting the materials on the basis of which a knowledge of the outer world is possible to man. But Brain is not the organ of Mind in the sense in which it is the organ of sensibility, for it does not produce the interpretation of its own excitation, as it provides for sensibility and excitation extending to the sensory cell. Mind alone interprets the experience of organism; it alone gathers and unifies a knowledge of the outer world.

The conclusions now reached are in harmony with the latest results of neurology. Electro-excitation of the brain has shown that a considerable portion of the central mass of the cortex may be regarded as associated with the leading forms of motor activity. All this portion may, therefore, be excluded meanwhile from our view, as bearing on the motor side of the system. Further, we have ascertained that both sensory and motor fibres radiate from the basal ganglia to the frontal and occipital lobes. We must, therefore, regard equally the frontal and the occipital regions of the grand central organ, as concerned with sensory activity and with correlated motor activity. But these regions do not respond to electro-excitation. Having regard first to the distribution of nerve fibres, there seems no reason to conclude that the frontal region is pre-eminently and specially connected with intelligence. Rather may we conclude that intelligence has its relations with all parts of the brain; and that all parts of the brain are concerned with both sensory and motor activity. Having regard next to the intercommunication clearly provided for within the brain, and the co-ordination of sensory and motor centres, and the general government of the whole organism through the nerve system by the agency of the brain as the grand centre of the whole, we can readily allow that a large part of the organ may be inaccessible to electro-excitation, since a large amount of inhibitory or restraining power must be exercised within the brain, in order that the manifold requirements of the nerve system may be adequately met.

If next we consider the whole conditions of human life from the standpoint afforded by the doctrine of an immaterial Mind, existing in constant vital relation with Brain, and with the whole nerve system through it, there is an important sense in which we may say that Brain is an organ of Mind, in constant activity as Mind is active. That there is an absolute harmony involving a parallelism or correspondence, and making an exact equation of both organic and non-organic activity in all cases, it is quite impossible to maintain. A large number of facts has emerged destructive of such a hypothesis, popular though it be, and regarded by some as a truism.

A theory of the relations of Mind and Body, however much of a hypothetical nature it may include, must be formulated in view of these two facts: that sensory excitation cannot be traced beyond the nerve cells into consciousness; and that physical and mental facts do not move in exact parallelism.

Mind as self-directing intelligence exists in vital relation with organism, contemplating organism as a constituent part of individual life, to be governed under rational law, as well as physical law. The relation of Mind and Body is thus so close as to involve *a unity of life.* Body so acts on Mind, that Mind cannot shut out somatic influences. Mind so acts on Body that in human history the body performs only a limited range of its functions without intelligent direction. The unity is that of a rational life manifesting itself in a rationally directed physical life. Further, our life involves *a duality in the unity.* Mind recognises Body as distinct from itself, while related. This duality cannot be detected from the physiological side, but is distinctly recognised in the ordinary actions of mind. The range of functional activity in the two cases differs greatly. Continuous activity of the special senses involves much more than Mind can observe and systematise. Intellectual life, on the other hand, far outstretches the impressions made through sensory apparatus. As Dr. Ferrier has said (*Functions,* p. 294), much of the brain's activity is "below the domain of consciousness;" and so much of it "involves consciousness," that is, I understand it, does not take place without consciousness, which, however, does not include a recognition of brain action. And here the separation of Mind and Body becomes conspicuous from the side of Mind. Mind does not know the sensorium, but only occurrences at the periphery; and does not knowingly control motor centres, but only muscles, quite remote from these centres. As concerned with its own organism, Mind deals knowingly with that portion which comes into direct contact with the external. But Mind transcends all the sensibilities of our organism. The whole range of our thoughts,—as we interpret events under the law of causality, form conceptions of rectitude, and represent to ourselves a scheme of the universe as a whole—transcends all the functions of the nerve system. Known facts are in accordance with this duality; paralysis of a cerebral hemisphere may leave intelligence unaffected; though high intellectual life involves good brain development, high brain development does not necessarily involve a distinguished intellectual life; but the more highly educated a man is, so much the more does his life transcend what his bodily functions can accomplish.

CHAPTER IX.

EXPERIENCE AS CONNECTED WITH MOTOR ACTIVITY.

THE facts representing activity of the motor system fall next to be considered, as they are closely connected with those attending on the activity of the sensory system. The relation between the two systems is very intimate. They are, properly, two divisions of one system, the one of which cannot be contemplated altogether apart from the other. This relationship will, therefore, determine the order of inquiry in the present instance.

First there are the facts which illustrate *reflex action*, or motor activity induced by the sensory apparatus, sometimes without consciousness on our part, at other times with a consciousness of the impression. Distinct from these, we find examples of motor activity which cannot be traced to any sensory impression, but depend upon personal determination. And still beyond these, we reach a class of non-organic actions which cannot be explained by any recognised activity either of the sensory or of the motor apparatus.

Dr. Marshall Hall showed (p. 80) that a sensory nerve may be an "excitor nerve," and that many of the sensory nerves are capable of providing for motor activity through the spinal marrow.[1] "The *vis nervosa*, or motor influence, acts in directions from the branches of the nerves towards their trunks into the spinal marrow, and upwards as well as downwards in the spinal marrow, . . . and lastly in reflected directions into the extremities."[2] Such action is illustrated in the case of a decapitated animal while the vitality of the nerve system remains. Stimulation taking effect at the extremity through a sensory nerve, reacts in movement of that extremity. A duck will run for a considerable distance after being decapitated; a tiger has been known to run for half-a-mile after having been shot through the heart.[1] In our ordinary experience, a touch on the border of the eye-lid leads to its instantaneous closing. If we only make a beginning in walking, contact with the ground will so act upon the sensori-motor apparatus as to keep up the exercise. In this way many of the actions of the living organism are explained, as in respiration and swallowing. These then are examples of reflex action, a phase of motor activity illustrated in the lowest forms of animal organism (see above, p. 123). Such activity is in many cases accomplished in the higher orders of animals without interposition of the cerebrum. Reflex action is, therefore, the most complete illustration of similarity in functional activity of nerve organism up the whole scale of animal existence, including the physical nature of man as the most elaborate structure of the whole. Upon reflex action there is no need for enlarging here, as it has been fully illustrated, and does not involve any question as to the relations of brain to mind. As already said, Reflex Action within the organism is the antithesis of Intelligent Action.

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[1] *Diseases and Derangements of the Nervous System*, p. 42.

[2] *Ibid.* p. 43.

From this common level of purely reflex action we rise a stage higher to take account of *sensori-motor activity, involving consciousness of sensation and observation of muscular action following.* The laws of sensori-motor activity continue exactly the same, and have been fully considered, p. 201, but, in association with mechanical nerve action, and as a clear addition to it, there is exercise of observation, and there is interpretation of the occurrence, these being examples of intelligent activity described in the previous chapter.

Thus it is, in connection with the motor system, we find distinct evidence of mental action, which cannot be brought under the laws applicable to the apparatus by which muscular activity is secured. We find here a complete separation from the facts of animal life. For, whereas animal activity is essentially reflex or sensori-motor, originating either in external impression or in visceral excitation, there is a large amount of the physical activity in human life which cannot be so explained. So far as purely sensori-motor activity is concerned, the laws of muscular action are the same for man as for all animal life. But, we have seen that so soon as we enter the field of reflective exercise, we have parted from the domain of nerve-law, and are dealing with the functions of Mind. A further illustration of mind-power is now reached when we contemplate muscular activity which has not its occurrence accounted for by sensory impression or visceral excitation, although the laws of motor and muscular action continue the same as when the action can be classified as one exclusively sensori-motor. There is thus presented to view the wide region of voluntary muscular activity.

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[1] "Afterwards upon opening this tiger, we found it had been *shot through the heart*, and had actually run full half-a-mile after receiving the mortal injury."—Bradley's *Narrative of Travel and Sport in Burmah, Siam, and the Malay Peninsula*, p. 83.

This phase of action, as distinct from sensori-motor activity, is so familiar to us in daily life, that it has become habitual to describe a set of actions performed by the lower animals as "voluntary actions." This practice makes it needful to guard with special care the philosophic significance of this term, "*voluntary* action." As sensory action is the antithesis of intellectual, so is action of motor apparatus the antithesis of volitional,—the voluntary element being recognised not in the nerve action but in a prior volition. Whatever activity is accomplished simply by a motor apparatus, existing in vital relation with a muscle, and started into activity by the sensory apparatus, is non-voluntary. That is to say, there is no action of a power of Will involved. The whole is included within the single course of mechanical action propagated through the central organ, from the one division of the nerve system into the other. But when we reflect on the line of action to be preferred, and decide on seeking a given result by use of physical appliances; while the muscular exertion is fully explained under physiological law, the origin of the act is to be found within the region of mind, where reflection is prosecuted, and where purposes are formed.

With this view of the functions of Will, the details of which will appear shortly, it is clear that there is a misapplication of the descriptive phrase, "voluntary action," whenever it is applied to activity for which a sensori-motor apparatus is sufficient. When, therefore, it is established that a phase of action is sensori-motor, and this action is nevertheless designated "voluntary," we confound things which differ. "Volition" is not the name for "spontaneous movement" such as occurs when an animal rises from its rest, stretches itself, or lies down to rest. "Spontaneous movement" may originate under purely organic conditions, and when this occurs there is no volition. Such movement may be sensori-motor, even when it is not dependent on external impression, there being a distinct circle of sensori-motor actions whose origin is within the organism, and not dependent on external excitation. The whole activity of the sympathetic system illustrates this. On the other hand, a voluntary action is an action originating in an intelligent determination.

To speak of a frog exercising volition, is to confound spontaneous action with voluntarily determined activity. However natural such language may appear, because of common usage, it is misleading and quite unwarranted. Yet nothing is more common in scientific discussion. An illustration may be taken from Dr. Foster's *Text-Book of Physiology* (p. 608), when the author is describing the results in the life of a frog consequent on removal of the cerebral lobes. He says, "A frog from which the cerebral lobes have been removed, even though all the rest of the brain has been left intact, seems to possess no volition. The apparently spontaneous movements which it executes are so few and seldom that it is much more rational to attribute those which do occur to the action of some stimulus which has escaped observation, than to suppose that they are the products of a will acting only at long intervals and in a feeble manner.' Even those who agree with the conclusion here indicated, which we think to be undoubtedly the correct one, may nevertheless take exception to the use of the word "volition," as seemingly carrying the assumption that a frog in its normal condition exercises will-power in the same sense as man, to whom we attribute voluntary action. It is obvious that Dr. Foster is here using voluntary movement as synonymous with "spontaneous movement," whereas volition and spontaneity are the antithesis of each other,—spontaneity belonging to organism, when intellectual direction does not occur, voluntary movement being that which takes place as the result of a deliberate determination, fully formed before muscular activity had a beginning. Muscular movements determined by the muscular sense, may be described as spontaneous. It is manifest that they cannot warrantably be called voluntary, for there is no volition involved. Of such actions, as already said, we have an illustration in the continuance of walking exercise without volition. To this class must be referred the muscular activity of the frog when not deprived of the cerebral lobes. In comparing a frog when deprived of these lobes, with another frog in its normal state, Dr. Foster says, "Both are machines; but the one is a machine and nothing more, the other is a machine governed and checked by a dominant volition" (p. 609). That both are machines, we readily admit; but the contrast between the mode of working in the two cases, does not seem accurately stated. It appears to be nearer the truth to say, that the one is a machine incapable of acting spontaneously, the other a machine capable of doing so. For we are apt to be misled by the experiment on a brainless frog. The facts are indeed clear. We must touch the animal, or push it forward, or alter its equilibrium, in order to make it move; in its normal state, the animal moves spontaneously, that is by impulse from within. But that the frog in its natural state, deliberates, considers a variety of possible courses of action, and intelligently decides for one of the number, we cannot affirm; whereas, all these are essential for government of the life by will. In the normal life of the frog there is no evidence of a dominant will.

Having, then, regard to the facts of animal life, and including human life in so far as it is animal, it should be observed that an exceedingly intimate relation subsists between the motor system and the sensory, when the former is conspicuously active. With muscular action there is commonly conjoined action of muscular sense. It is by this means that we are able to connect the facts of consciousness, not only with sensory impression, but also with motor action. Besides this there is, by the laws of co-ordination applying within central organs, a continual correlation of sensory impression along with motor. Accordingly it happens at one time that sensory fibres are auxiliary to motor fibres, when the latter have the main part to perform; and at another, motor fibres are auxiliary attendants on sensory activity when afferent nerves chiefly occupy the field of action. Dr. Foster presents the facts most clearly in these words:—"It cannot be too much insisted upon, that for every bodily movement of any complexity, afferent impulses are as essential as the executive efferent impulses. Our movements are guided not only by the muscular sense, but also by contact sensations, auditory sensations, visual sensations and visual perceptions (for the remarks made concerning the relations of the co-ordinating mechanism to consciousness do not exclude the possibility of consciousness affecting the mechanism; indeed, not only may perceptions enter into the causation of vertigo, but even an imaginary idea may be the sole exciting cause of this condition); and when we say 'they are guided,' we mean that without the sensations the movements become impossible" (*Text-Book of Physiology*, by M. Foster, M.D., Fourth edition, p. 619).

We proceed now to treat more expressly of the *voluntary element* in human activity, which cannot be interpreted by reference to the motor apparatus, either singly or in its relations with sensory apparatus. We are here brought to the threshold of the whole problem concerning will-power. The problem is vast and important. It includes not only questions as to muscular activity, but also control of thought, with all that is concerned in concentration of mind; government of our feeling, even of the strongest passions, in order that life may be directed by reason; and formation of moral character. Meanwhile attention may be restricted to control of muscular activity. Will-power works in relation with nerve force, but it is recognised as distinct from it, and this distinction is made quite clear on account of the diversity of law operating in the two cases. The one power even comes into competition with the other, thereby affording the best possible means of experiment in order to establish the difference. Examples are not difficult to find, being plentiful under our general liability to suffering. Voluntary endurance of pain in any form, without shrinking, introduces the new element, presenting a contrast to ordinary motor activity. It may be exemplified in mere diversion, as in the case of an American cadet, who on a warm summer evening, bared his arm and endured mosquito bites without wincing, until an artful comrade, coming behind, tried him with the point of a red-hot wire. Self-restraint in checking nerve action often, in the surgical wards of our public hospitals, illustrates high courage. It is recorded of an able-bodied seaman that, after having quietly submitted to an operation, he cried out when a needle was run into his arm by the dresser when binding up the wound. The dresser expressed surprise that one who had endured the operation itself so quietly, should cry out under the puncture of a needle. To this the sharp-witted tar promptly replied, that he expected the cut of the knife, but he did not expect the prick of the needle. Expectation, with the preparedness of mind it implies, makes all the difference, and this difference is as wide as the distinction between voluntary and involuntary action. Two forces meet each other, the will-power masters the nerve-power, the result being inhibition of motor activity; that is, an effectual restraint is put on the ordinary law of action, which regulates the sensory nerves and cells, with the correlated motor cells and nerves.

There are, no doubt, certain physical characteristics which have a bearing on the balance of motor activity and will-power. There are persons of a more acute sensibility for whom even a slight form of injury is much worse to endure than greater injury is for others. There are conditions of physical prostration in which extreme nervous irritability makes muscular control next to impossible. Such a case illustrates the ascendency of the physical, with the temporary subjection of the mental power. And there are cases in which a patient passes through the earlier stages of a protracted operation with great self-command, and yet completely loses control during the later stages of it, vanquished by exhaustion and anxiety as to the result. But these, and similar considerations, throw no doubt over the distinction between the laws of motor activity and those of will-control.

The contrast of power of Will and muscular energy thus becomes very marked. The laws of motor activity which regulate the nerve system are perfectly definite. The infliction of pain involves a convulsive movement of the sensory nerve; this operates upon the sensory cell, whence the impulse is communicated to the motor cell, and thence by the motor nerves to the muscles. But what we have, in addition to this, and in direct contrast, is a restraint imposed upon the natural action of nerve force along the double line. It is true that inhibitory action is characteristic of some parts of the nerve system itself. Thus certain conditions of body imply an inhibitory action, through the nerve system, upon the heart, or lungs, or stomach. But there is no law applicable to the sensory and motor apparatus which implies the imposition of a check on the transmission of the impulse communicated at the peripheral extremity of the sensory nerve, when an incision is made. Spontaneous shrinking is the one inevitable result under the laws of nerve action.

On the other hand, it is matter of clear and unquestionable experience, that personal determination is the explanation of the restraint imposed in such cases as those to which I am referring. The contrast between preparedness and unpreparedness for endurance is the presence or absence of personal determination to endure suffering for a clearly recognised end. And the evidence is most striking, as it is most valuable for the present purpose, when endurance of suffering does not take place under pressure of a greater agony to be escaped, but under a quiet and deliberate resolution in order to avoid an anticipated yet remote result. For demonstration of the present point, there is great difference in the value of the evidence coming from the sudden resolution to submit to the extraction of a tooth on account of incessant torture from severe toothache, and that coming from the quiet determination to submit to surgical treatment when there is no present suffering to awaken a powerful desire for deliverance from pain, and when the advice of a skilful practitioner is the only ground for submission. A dog suffering torture will put itself in the hands of a familiar and trusted keeper, and submit to increase of suffering while a thorn is being extracted, without showing any disposition to bite his benefactor. But dogs troubled with a swelling on the limb do not consult, do not listen to advice with which a consultation closes, and do not deliberately prepare for the operation which veterinary skill may suggest as desirable in the case. It is deliberation first, and power of control over nerve action consequent upon such deliberation, which together illustrate the strength of will power in conflict with nerve power. In such a case it is not mere power of endurance which is tested. That may be tried in the experience of any sentient being. It is power of self-control for a contemplated result to be reached in the future, and not merely for present escape from insupportable anguish.

From this I pass to the *third* and higher phase of action, where *motor energy is brought into use as the servant of intelligence and will,* in absence of any sensory impulse, or physical condition, which could account for motor activity under laws regulating the nerve apparatus. In our experience there are examples of motor activity not explained by sensibility to external influence,—nor by the power of the cellular tissue in the cerebrum to evolve nerve energy,—but which are accounted for by previous deliberation on our part, and consequent determination to act for an end which has already been matter of choice. The actions referred to are not of any singular or high order illustrating peculiar power, but are such as occur in every man's life all hours of the day. Every man using a tool in handicraft, every one uttering a sentence in expression of his thoughts, every person writing a few lines for the same end, illustrates the ascendency of intelligence and will over the motor system. There is no need at this point for founding anything upon the additional plea that handicraft, and spoken discourse, and written language are peculiar to men, distinguishing them from lower animals. These actions are illustrations of a fundamental feature of human life, regulation of motor activity by personal thought and purpose, and it is better to deal with the fact of such regulation, as exemplified in thousands of cases, even where human actions, so far as outward appearances indicate, closely resemble the actions of the lower animals. I take them, therefore, only as examples of a distinct class of human actions.

The new features involved will be most readily ascertained by taking a familiar example. Skill in workmanship by the apt use of tools involves considerable variety of action. In applying the tool to wood or other material, the motor apparatus is brought into use, giving exercise to muscles, nerve fibres, and motor cells. Such actions depend, in the first instance, upon contractility belonging to the muscles, and excitability of the nerves which bring the muscles into action. Thus far the originating power is in the nerve cell. But an explanation of the activity of the nerve cells is required. There is a selection of nerve cells and fibres as those which alone are suited for bringing into exercise the muscles of the two arms required for management of a tool. But cells, fibres, and muscles are not objects of contemplation to the worker. His concern is with the material and the tool, and with his own purpose or intention in the use of them. The matter of interest to us is what takes place before the tool is lifted and directed; and thereafter how much is involved in acquired skill of the workman, resulting from frequent return to his work. The very simplest aspect of such work includes observation of the tool to be used, and of the material to be worked upon; determination to grasp the tool and apply it; a definite plan or purpose as to what is to be accomplished by means of the work; and continual exercise of intelligence and will as the work proceeds, adapting each movement so that it may contribute to the desired end. The primary exercises of observation involve mere sight of the tool and of the material. In a sense this observation may be quite possible to an animal such as the dog, though there may be reason enough for supposing that, to the dog, a chisel or plane is merely a thing, and not a tool or instrument; and that the piece of wood is only a thing, and not material out of which some other thing may be produced. The sight of the tool and the material goes a very little way towards explaining the action of the workman. The knowledge which physiology affords as to the laws of action of the motor apparatus is an additional contribution towards the explanation. When, however, we have combined these two elements—sight and its influence, the motor cell and its impulse—the main part of the explanation is wanting. The origin of the action, the intelligent purpose of continued work, and the sustained effort extended over a considerable time, suspended for a season, and renewed again: these are the most important features in the case. Without these the action is reduced to a lower level, and becomes nothing more than mechanical exercise of a reflex type, such as is exemplified in a person continuing to walk along the street. But some understanding of his work, some conception or ideal of what is to be made, and some regard to size and proportions, are essential before the work is begun. All these are personal occupations of which the moving arms give no tokens; they are essential antecedents of motor activity, which is only the mechanical consequent of volition. Intelligence is needful for handicraft, and it is in the same sphere as that in which the intelligence works, that the determination is formed which originates motor activity. Until that volition is formed, there is no motor impulse; as soon as the volition is brought to bear on the organism, the motor impulse speeds on its way, and forthwith the muscular energy is liberated and actively at work. We may calculate the time involved in the course of motor activity, just as it has been found possible to reckon the time taken to experience an impression made on a sensory corpuscle. But in the order of events, thought will come first, and volition or self-determination second, as facts known with certainty, that is, elements of our own experience, while thereafter we allow for excitation of the motor cell, then of the nerve, and ultimately of the muscle, facts which are not known in experience, but which are admitted on scientific grounds to be the organic conditions of the visible activity of the arms. We are here dealing with successive features of personal action which are indisputable. Thought is the origin of volition, and volition is in this case the cause which liberates nerve energy, and the nerve energy becomes the cause which liberates muscular energy. If the relation of the two first-named actions to the muscular activity be disputed, it can be made matter of experiment. A resolution will be sufficient to lift the tool at any moment; resolution not to touch it will suffice to keep the arm at rest, and even to throw it into a rigid attitude if any attempt be made by others to bring the hand into contact with it against our will. As to the facts, including thought, volition, nerve action, and muscular action, there is no room for doubt;

the certainty as to the two first being that of experience, of the two last that of scientific testimony.

Possible controversy is thus restricted to the theory which may be propounded by way of accounting for the two first facts. The theory that action and reaction of nerve tissue carries the explanation of all that belongs to human life must try itself here,—must here make good its claims, or fail utterly. It has been said that "all soul-life is ultimately referable to the two elementary functions of sensation and motion, and their conversion into reflex action." What is required is demonstration of the assertion in the case before us. Here is the motion,—industrious use of the arms in the exercise of mechanical art. Where is the sensation and where the evidence of a reflex process from sensory activity to motor? To suggest that the sensation of grasping the tool causes the action which leads to its use would be of no avail. The suggestion is at fault on both sides. In the case of continuous action it may be admitted that the sensation involved in grasping the tool contributes some stimulus to the motor apparatus brought into activity, but this would be a continuous, uniform impulse as long as the activity lasted, and would not account for the origin of activity, or for regulation or guidance such as is involved when the results of handicraft are worked out. To make plain the distinction between reflex and regulated activity when they commingle in the same occupation, let us take the illustration of weaving, where the worker uses the treadles and the shuttle. The pedal and the manual work illustrate the two opposite conditions of activity. There is voluntary exercise in starting the whole process, for the work is one, as it is one man's work, and depends upon personal resolution for its being attempted. But when it is begun, the feet follow the hands, not the hands the feet. The manual activity is the determining feature. And if we inquire how this appears, the answer brings out the distinction. The eyes are guiding the hands, but they are not in the same way directing attention on the movements of the feet. And the guidance of the hands by sight is regulated according to a pattern hung within reach, and which is constantly being compared with the web, while the shuttle flies backward and forward. The feet are playing an essential but quite subordinate part; nerve sensibility is enough to provide for such activity, and their movement will continue without direct intention so long as there is nothing to disturb. The hands, in like manner, are doing an essential part, but theirs is a far more important part, and illustrates action of a higher order. Intelligence is not directing the feet, intelligence is directing the hands. Under guidance of eyesight, the hands are working out what the worker aims at producing; and any deflection or deficiency is not only seen as fact, but recognised as departure from the design. By personal determination the hands are stopped, as by the same means they were kept in motion, while, as an inevitable consequence of what has happened, the feet are stopped as a mere mechanical result, without any express determination concerned with their activity. The manual activity is voluntary, the pedal is reflex; the latter is explained by the laws of activity which belong to a sensori-motor apparatus, the former is not. A case in contrast is presented in playing upon the organ, where feet and hands are equally engaged in the same exercise, all four being employed in execution of the piece of music. Here feet and hands together illustrate voluntary movement, an illustration which is of special value, as showing how the single power of will takes complete control of a whole series of cells, nerves, and muscles determining their co-operation for a harmonious result. If, then, we take a phase of handicraft in which the feet are not engaged, but the whole work is done with the hands, we have an example of muscular activity which is throughout voluntary, that is, continually determined by exercise of will power, in contradistinction to activity which is accounted for by sensori-motor relations. To suggest that the grasping of the tool is sufficient to account for the manual labour done by skilled workmanship is to overlook the direction which the eyes give to the hands, and to forget the light of intelligence thrown from the inner sphere, as well as the sunlight from the outer. It is to forget the essential difference between mechanical action and voluntary activity,—the difference between the machine and the worker. The machine can work as well in the dark as in the daylight; not so the artificer. Reflex action may readily enough be done by men without light to guide; it may even be continued when the agent is fast asleep; but voluntary activity can be done only when the agent brings the directing power and the controlling power belonging to his personality into effective exercise. The muscular activity of man is not all of a single type, and does not admit of being brought under a single form of explanation. There is reflex activity, and there is voluntary. The attempt to identify them is a failure. A sensori-motor scheme is insufficient to embrace the most simple and familiar forms of human activity.

Passing from the illustration of reflex action, suggested as the normal type of all muscular action, we have now to contemplate more particularly the origin of such action as is exemplified in ordinary handicraft. Here we must inquire what is the exact nature of will power,—what we mean by personal resolution or determination, as an alleged fact standing at the opposite extreme in human experience from sensory impression, in which some would affirm that all muscular activity originates. Here also we must try the suggestion that the action and reaction of the nerve system is adequate to account for human activity. What we mean by volition or exercise of will power is best shown, in the first instance, by marking its contrast with nerve action. It is not that which moves the muscles, but that which moves the nerve cells to act upon the muscles. It is not that which moves the limbs, but that which determines that they shall be moved. In its lower and simpler aspect, this may be illustrated by reference to sensory activity. A falling stick touches the hand, or a neighbour jostles the elbow. By contact of some external body, an impulse is given to the sensory nerve which is transmitted to the sensory cells. Let us turn now to motor activity. In so far as the originating power *acts upon* the motor apparatus, its action is, in a sense, analogous to that which produces tactile impression,—it operates as an external power, that is *external* to the apparatus. Or, to take a form of expression more familiar, there comes from an inner sphere, from the region of personal experience, an impulse which acts upon the motor cell, and throws it into activity. That which acts upon the motor cells is as certainly external to the system as is the object which comes into contact with the sensory system. But in the case of voluntary muscular activity, that which operates acts directly on the cell. And what is not reflex, as not being the product of movement of the sensory nerve, must be accounted for by power from some other quarter, that is, from a sphere external to the nerve system, though within the nature of the person. The working of the arms by any craftsman is not a case of spontaneous working of the nerve cells. It is not alleged, in such a case, that nerve cells evolve nerve energy simply because their supply of energy is so great that it seeks outlet, or forces for itself a path of activity. The activity is, indeed, impossible without nerve stimulus and muscular energy, but its present manifestation and direction are not explained by these, but by the workman's purpose. Consequently, this purpose must be something distinct from the motor apparatus,—something which acts upon it,—just as certainly as the sensory apparatus is shown to be distinct from the motor on which it acts. By this merely negative test the theory of action and reaction *within* the nerve system is brought into perplexity. The facts of motor activity require further explanation, some power external to the motor apparatus, just as obviously as the facts of sensory activity. These two divisions of the nerve system act singly as well as unitedly; and in the former case the communication of impulse must come from beyond the apparatus itself. The personality of the agent operates on the organism which belongs to him. The "clavier theory," which likens the action of mind on organism to playing on an instrument, and which we rejected when discussing sensory activity, is a form of analogy more nearly allied to the facts of motor activity. Here, mind acts upon motor cells, inducing functional activity in them, and down the motor nerves to the muscles. But even here the analogy is unsuitable, for, in using motor apparatus, the person does not know that there are motor cells, and does not wittingly operate upon them, and never learns to do so. The agent knows only his own purposes, wills accordingly, looks for the execution of his volition in the action of his organism, and finds it realised in visible action according to his expectation.

I now take the more positive side of the problem. What is to be said of the Will, as the power which acts upon nerve power? The facts of personal experience supply the answer. These facts alone can provide evidence on which our account of will power can proceed. The facts are familiar, much better known than those connected with nerve action. Their nature will be best indicated by passing from motor activity and its apparatus, to consider the true rise of voluntary muscular effort. A craftsman has some conception of an object, or some plan before him of an article to be manufactured; he occupies himself with the best methods for its construction; he resolves to make the attempt, and by an act of his own will he gathers his tools around him and begins work. It is exactly in the same manner the artist begins who would produce a picture, and the author who would write a book. Thought and will are connected in this early stage, which is the true commencement even of muscular action, when it is properly described as voluntary. So it is when a person gives audible expression to his opinion on any question. His thoughts on the question, and the feelings awakened by them, are not the cause of utterance. Such thoughts and feelings are often present in his consciousness, without finding expression. No occasion seems to arise for uttering them, or at least he feels no inducement in the circumstances. At times, when the thoughts and feelings are present, silence as to their nature is matter of personal determination. There is a deliberate purpose to refrain from expressing his thoughts. And when he does speak, he wills to use his voice, and guides it in the process of articulation needful to convey to others what he wishes to state. The process is still the same when he records his thoughts by writing. As in the previous case, he wills to formulate his thought, ponders the matter, and selects carefully the fittest forms of expression. The sole difference is found in the muscular apparatus he brings into exercise. He now wills to use the muscles of his arm, and by aid of the pen he produces the written characters which are conventional signs for his meaning, easily interpreted by those familiar with the language he employs. Personal determination or will is the origin of all three actions. The points of difference and of similarity in the three cases bring out the common feature connected with their commencement, namely, volition. In a sense the three actions are similar throughout. They are only different examples of the same class of actions, known as voluntary muscular acts. All three begin in an exercise of personal determination or power of will; all imply activity of motor apparatus; all involve efficient use of muscular energy; and all accomplish a previously contemplated and intelligent end. In certain aspects each action is different from the other two. The difference is found in what belongs to the outer field of activity; the closest resemblance in what belongs to an inner and invisible sphere of action, the sphere of experience proper, where we have actual certainty. The difference is concerned with different sets of nerve apparatus, and different sets of muscles, the local difference being considerably more marked when we compare vocal expression with manual exercise in the use of a sharp-edged tool, or in wielding a pen. The similarity consists in the exercise of will power, which equally originates all three actions. When we compare these three volitions, we can only speak of them as successive acts of the same power. Reference to local differences, such as is fitly made when we speak of the action of nerves and muscles, entirely disappears as inapplicable. These volitions are simple exercises of a power of control over our organism which we find ourselves to possess. So thorough and simple is this control, that it is possible, by mere act of will, to use at the same time the organs of speech, and the muscles of the arm and hand required for the act of writing, or for use of a sharp-edged tool. The unifying power which harmonises the action of nerves and muscles far apart is the Will Power which governs both. How the Will exercises this control over the cells, fibres, and muscular tissue is unknown; but that such control is exercised admits of no doubt; the result being normal action of nerve and muscle, according to the purpose of the agent. What takes place within the physiological sphere is a liberation of nerve energy, propagated along the motor nerve, and communicating the impulse needful for liberation of muscular energy, which thenceforth continues to work according to the Will's behest, and is instantly stopped when the Will decides upon cessation of effort. The truth illustrated by the large multitude of muscular acts properly described as voluntary may be included under some such formula as the following:—Man has the mastery of his organism, so as to determine the use of its muscular energy in the field of exercise appropriate to it, and within the limits assigned to it. If in individual history this mastery be abridged, as in cases of motor paralysis, disease has been induced, and an abnormal condition established. But, according to the constitution of our being, and consequently in accordance with the laws which regulate the correlated activity of thought, volition, nerve, and muscle, it is the normal condition of human existence that intelligent control can be easily exercised over bodily movements.

On the ground to which this conclusion has brought us, we are completely beyond the region within which any theory can be applicable which relies exclusively on the action and reaction of sensory and motor apparatus. The only hypothesis which such a theory can present is this: that beyond the range of sensori-motor activity there are still other correlated cells and fibres by the action of which thought and volition are induced; that by some obscure and mysterious process the thought cells become active; that these, by evolving intellectual energy, propagate movement along an intellectual fibre; that this intellectual fibre communicates an impulse to a volitional cell, causing it to evolve voluntary energy, propagating movement along a volitional fibre; and that this volitional fibre moves the motor cell by the action of which on the motor nerve the muscle is set in motion. This is a hypothetical scheme, constructed according to the analogy of the sensori-motor system, and intended to embrace the wider range of facts known as intellectual and volitional. It is supposed that such a theory is favoured by the general acknowledgment that a central governing power belongs to certain portions of the cerebrum, and also by the fact that the frontal and occipital lobes yield no response to electric stimulation, while the greater part of the central lobes, upper and under, yield a ready response. This is the theory which must find favour with those who believe that all human activity can be explained by "the irritation and contractility of animal tissue," or that "mind is a function of brain," and it must be explicitly accepted by those who are prepared for the very definite declaration of Cabanis, that "the brain secretes thought as the liver secretes bile." How far such a theory can bear the test of facts, and specially how far it is compatible with our knowledge of will power, must now be considered. And here, it is to be observed, that human experience alone can afford the test to be applied. Whether the lower animals exercise any such control over their actions as we do, when we speak of voluntary determination, there are no means of knowing. So far as the evidence afforded by their actions can be supposed to bear on the question, there is little to favour the supposition that rational self-determination belongs to them. The great majority at least of their actions can be accounted for by sensori-motor activity, and a very small margin is left for cases which may be held to leave some room for doubt. With human actions it is not, indeed, exactly the contrary, but the distribution is so different that when we have excluded the play of vital organs by means of the sympathetic system, only the smaller proportion of human actions can be attributed to purely sensori-motor activity; by far the greater proportion give evidence of voluntary determination. The completeness of this contrast occasions perplexity for any theory which seeks to account for all forms of human conduct by the action and reaction of sensory and motor nerves.

Considering the direction in which physiological inquiry proceeds, by study of the cerebro-spinal system, it was inevitable that a theory reducing all human action to the play of nerve force should be propounded. Such a hypothesis naturally arises as one of the alternatives to be discussed. A real service has, therefore, been rendered to scientific research in the department of physiology, and also to mental philosophy, by the attempt to include all forms of human activity under the sweep of physiological law. Only by means of a clear and certain rejection of such a theory on the ground of its insufficiency to account for the facts can there be a thoroughly instructed acceptance, under scientific and philosophic warrants, of the theory that man possesses a higher order of life than the physical, yet in entire harmony with his physical organism, and so governing it that the two constitute a unity of being. The question, then, is this—Is the exercise of Will Power as a familiar fact in personal experience of such a nature that it can be accounted for by a form of nerve action analogous to sensory or motor activity? Seeking an answer to this question along the lines suggested by the nerve theory, we shall see what claim that theory has to acceptance. Granting that some uncertainty still hangs over the action of nerve cells, what evidence is there to support the hypothesis that there are intellectual cells and volitional cells?

1. There is neither anatomical nor physiological evidence in support of the theory. There is clear anatomical evidence of two orders of fibres, sensory and motor, each one of which is directly connected with its own appropriate nerve cell; and there is equally satisfactory evidence that, at least in very many cases, the two sets of cells are so connected together that impulse can pass over from the one order of fibre to the other. Physiological evidence is in strict harmony with the anatomical evidence. (See above, Chapters III., IV., and V.) But there is no proof presented either by anatomical or physiological research of the existence of two additional orders of cells. There is no scientific warrant for maintaining an intellectual-volitional or volitional-intellectual order of fibres and cells within the cerebro-spinal system.

2. The theory, though purely hypothetical, has the merit of being formed in strict accordance with the analogies suggested by the sensori-motor system. The sensory apparatus and the motor, as they exemplify the law of action and reaction, afford the scientific groundwork on which are arranged the details of this hypothetical scheme of intellectual and voluntary activity. This must be acknowledged as a merit in a scheme of thought which claims to be regarded as illustrating "the scientific uses of imagination." But valuable as it is to have a scientific ground-work to guide us in the exercise of scientific inventiveness, it must be remembered that analogy proves nothing.

3. The facts relied on as auxiliary to the theory do not in reality support it. These facts are admission of governing or inhibitory power belonging to the frontal lobes of the cere-

brum; and the absence of response from the frontal and occipital lobes under electric excitation. That these two facts are clearly established by ample evidence admits of no doubt But if the frontal lobe has a governing influence, the fact may equally harmonise with either theory. On the theory that the brain is the organ of the mind, providing for government of bodily movements, both inhibitory and actively controlling power must belong to it, and these functions may be assigned to the frontal and occipital regions. Inhibition is a function not readily illustrated under electric excitation. But a thoroughly organic control must involve systematic arrangement for activity of any portion of the apparatus as occasion may require, and for the needful restraint in other parts. And this must apply to every brain.

Again, it is true that the frontal and occipital lobes are silent when the electrodes are directed upon them (see p. 117). While stimulation of the central portions of the brain proper leads immediately to distinct movements, there is no such response when the portions of the organ to the front and back are subjected to test. For the theory which finds the origin of all human activity within the cerebro-spinal system, there is some advantage here. These "silent regions" present a considerable unexplored territory, and so afford "locality," an element essential for such a theory. These "blanks" within the organism can be filled up with imaginary apparatus for intellectual and volitional activity. Only, this may be done as a draftsman can fill in a plan with a variety of objects which never had any existence. No scientific value can belong to such imaginative exercise. While "locality" is there, and it is an advantage to the theory that the *frontal* region is a part of that locality, these regions are silent in the brains of lower animals, such as the dog and cat, and it is the observation of their silence in such brains, not in the human brain, which has given rise to this speculation. This fact is unfavourable to the theory. There is inherent weakness in the argument which seeks help towards discovery of the key to the intelligent self-direction of human life, in the fact that there are certain regions in the brains of animals greatly inferior in intelligence of which *nothing* can be made by the most persevering use of electric stimulus. The perplexity is increased when we add the fact that, as we descend the scale of animal life, including animals of greatly inferior intelligence, the proportion of area yielding no response to electric stimulus is still larger. Dr. Ferrier records the results of his own observations in the following terms:—"The brain of the pigeon, as well as of the common fowl, on which I have also made experiments, though apparently constructed on the same type as the brain of rodents, differs from these in the fact that electrical irritation fails to excite analogous movements."[1] The "locality" remaining silent under the electrodes, and still requiring to have its functions determined, is seen extending before the view, but in the wrong direction, that is, down the scale of life and further away from intelligent self-control. On the other hand, a great amount of sensory and motor activity remains to be accounted for beyond the forms of action illustrated by electric stimulus, and the "silent regions" are largely needed to give room for the requisite nerve action.

4. The facts to be explained,—voluntary control of muscular activity under guidance of intelligence,—do not manifest resemblance to the known facts of nerve action, but present a decided contrast. To attain some reasonable degree of plausibility, the theory which allows only for action and reaction of animal tissue in human life must make out some degree of resemblance between the facts of nerve sensibility and nerve stimulus of muscular fibre, and the other set of facts, namely, intelligent deliberation as to means and ends, and consequent personal determination to put to use the muscular energy at command. But this the theory fails to do. Resemblance between the facts there is not; and in place of what is required by the theory in order to make good its claim to existence, there is a thorough-going contrast between the two sets of facts. The action of sensory and of motor apparatus is instantaneous and uniform under the normal conditions of activity; under the different conditions which apply to thought and volition, there are such successive stages in experience as suspense, deliberation, and determination. If the artificer work from a plan set before him, it cannot be said that his workmanship is explained

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[1] Ferrier's *Functions of the Brain*, p. 159.

by the impression which the light reflected from the surface of the plan makes on his retina, the transmission of influence along the optic nerve, the action upon the sensory cell, and the transmission of influence to all the motor cells concerned with the control of the muscles brought into exercise. If apparatus can provide for such work, we need more of it than the sensory and motor. We have such experience of what is involved in these cases, that we know there is a series of personal actions essentially connected with the work, and which are not included in the description just given. There is comparison of different parts of the plan, in order to gain an intelligent appreciation of it as a whole. And it is only when such a conception is obtained, that the craftsman attempts the task of realising by his handicraft what is present as a conception in his mind. So far is the conception of the plan from being a mere mechanical result consequent on the impression made upon the retina, that each workman has his own conception,—the beginner having a much less adequate conception than the experienced artificer. This difference of conception is in some degree dependent on the greater facility in the use of his powers of observation possessed by the experienced workman. But the chief part of the explanation is to be found elsewhere. It is found in the power of discrimination vested in an intelligent nature, and which, in the previous chapter, has been shown to be characteristic of man's use of the sensory apparatus. Hence the man of larger experience may be slower to begin his work than an inexperienced workman. And this suspension of muscular effort is the result of his own exercise of Will power. He deliberately holds in abeyance his muscular energy, in order that he may use to full advantage his power of intelligence. The distinctive feature of volition, as the exercise of a power of self-control, appears equally in the suspension of muscular effort, and in the direction of intellectual. The difference between a skilful and an unskilful workman may be variously expressed. We may say of the two men, each man sees only what he has the eye to see, or the one has not head enough, or perhaps has not brains enough, to recognise or attempt what the other does. But, when we test our meaning, we find that what is really intended is that there is higher intellectual work in the one case than in the other. And this intellectual action illustrates a higher exercise of Will power, namely, that kind of control which a man is capable of wielding over his own Intelligence. Any diversity of intellectual power between the two men does not obscure the distinctive place of volition. The difference of work in the two cases is not necessarily the result of higher intellectual gifts in the skilled workman than in the unskilled. For, the beginner, as yet so unfit to make full use of his power, may as the result of discipline and study prove himself able to surpass the man who was vastly his superior at an earlier stage. But such discipline and study imply continuous exercise of Will power, controlling sometimes purely intellectual effort, sometimes muscular effort so as to attain the manual dexterity needful for the outward expression of what lives in the mind. Will power finds exercise where intelligence operates, for volition is rational determination, in contrast with a mere sensory or motor impulse. It is in the midst of intellectual exercises, in the realm of Mind proper, that we find the seat of central government exercised by Will. And yet, though there is a difference, amounting to duality of being, between the intellectual and the physical, there is such harmony of the two, such unity by means of duality, that Will governs both with equal facility, directing the muscles in their work, as readily as the intellect in its reflection by means of deliberate exclusion of extraneous topics. The intellectual and the physical nature constitute one being, and Will directs the action proper to both elements of the one life. While, however, these two thus really constitute one being, and the unity is apparent in the unity of controlling power which the Will exercises over them, the two natures are so distinct that muscular power can be kept in a state of inactivity, while the intellectual nature is busily occupied. Yet the converse is not possible in the doing of any skilled work, for the intellectual nature cannot be left inactive while muscular activity proceeds. On the contrary, intellectual action is continually needed while the acquired manual dexterity is brought into requisition. The Will governs the muscular activity by means of intellectual insight determining the work to be done by the hands. Thus the Will is a power controlling the whole being, intellectual and physical, but a power which has its seat, and the source of all its dominion, in the mental or intellectual sphere. Human life is not governed by the action and reaction of sensory and motor apparatus. Its government is from an inner and higher sphere, within which the higher powers of man operate so freely, that the true personality of the man is seen in the voluntary exercise of the intellectual nature. What may be the activity of the nerve cells while the artificer is merely pondering his plan may be difficult to decide; that there is a large amount of work done by the nerve cells while he is engaged with his manual effort we have clear and abundant evidence to prove,—evidence not drawn from any experience we have in such cases, but obtained by physiological research. Restricting attention first to physiological evidence, the position is this—absence of evidence in the one case, abundant evidence in the other. Turning next to the facts of experience, we know certainly that by exercise of Will we set the muscles into action for the accomplishment of work, and we voluntarily stop their activity. In like manner, we know that by the same Will power we govern our thoughts. Further, we know that this Will power is essentially connected with our intellectual nature, as a discriminating or seeing power, insomuch that the voluntary direction of muscular activity is intellectual direction of it, and intellectual direction is voluntary. Putting the case most guardedly, there is no evidence that nerve action produces volition; there is clear evidence that volition controls nerve action. When this control is examined, it is found to be something more than mere determination of nerve action by communication of impulse, such as occurs when an external object comes into contact with a sensory nerve. There is communication of impulse to the motor cell in some way unknown to us; but there is in addition, what is not found in sensory activity under tactile impression, or in reflex activity of the motor system, discrimination of possible forms of action, and determination of a particular line of action by personal purpose, on intelligible grounds, and for attainment of a selected end.

Thus we recognise in personal activity a ruling feature, most conspicuous in human life, which stands in complete contrast with all that is known of nerve action, and consequent muscular activity. In obedience to volition, the motor impulse goes from the motor cell, just as the sensory impulse goes instantaneously from the touch-corpuscle after tactile impression. But before the volition there was suspension of all muscular action,—there was voluntary reflection, turning first in one direction, then in another; as the result of comparing these different lines of thought, there was the formation of a definite resolution as to how to act, and the volition to use the muscular energy came later, as the result of all this prior intellectual and voluntary activity, which gave no visible tokens of its procedure, save the expression on a preoccupied face. All this prior action, with its double aspect of Intelligence and Will, is entirely different from the instantaneous and perfectly uniform play of nerve energy under appropriate excitation. This conclusion may be most strikingly confirmed by detailed reference to the work of the artificer or higher artist, who works, not from a plan or copy presented to his eye, but from an ideal conception which has no existence save in his own mind; but there is no need that this wider course of evidence should be added to confirm what the lower and more ordinary forms of action clearly establish.

Having now some definite account of what is meant by self-control of our whole nature, as illustrated by muscular action, we are in a position to remark upon the distinction adopted in physiology between "voluntary muscles" and "involuntary muscles," previously mentioned (p. 45). Distinguishing between the action of the sympathetic system and of the cerebro-spinal system, it is not unnatural to introduce a reference to volition as pointing to some ground of distinction. But it needs to be observed what this distinction really is, and how much it involves as illustrating certain characteristics of human life. We speak of voluntary and involuntary actions; but while this is in point of form a classification of actions, it really amounts to a double use of the word "action." In the one case the type of activity involves the action of the whole being,—the man as man acts. In the other case it is not so; the type of activity is not an action of the whole being,—the man as man does not act. We speak of the action of the heart, or of the lungs, but this is a mere organic act,—a spontaneous movement of a vital organ, requisite for physical existence. It is movement rather than action,—the movement of vital organism, characteristic of all animal life. It is essential to animal life, but is not characteristic of the higher, self-regulated life of man; it is not, in any proper sense, a human action. It is as regularly performed in the life of the unconscious infant as in mature life; in sleep, as in waking hours; in the unconscious state induced by chloroform, as in the hours of active exercise. If, from such actions, we pass over to muscles named "voluntary muscles," can we describe all their "actions" as "voluntary actions"? We can not. Prick a man's hand, and it is instantly withdrawn,—that is involuntary. The man stretches out his hand to lift a book from the table,—that is voluntary. What is the difference? In the first case, the man as man does not act. Sensibility of nerve fibre is sufficient to account for all that is involved. In the second case, the muscular action is as simple as in the first, but the man as man acts,—there is intelligence and personal purpose in the action. It is not the result of sensory stimulus, or of physical craving, or of irritation operating within any part of the organism. Simple as the action is, it illustrates a higher phase of life, an exercise of control, which is not a uniform characteristic of animal life. Thus the distinction to be drawn between two different phases of action (which are nevertheless accomplished by the use of exactly the same nerve appliances), introduces us to the difference between a lower and a higher phase of life, and points directly to the pre-eminence of man, as he is capable of intellectual and voluntary activity. To speak of a sheep grazing, or a dog hunting, or a horse running in a carriage, as illustrating voluntary action is a misapplication of terms. It is to confound things which differ,—to mix up in confusion things lower and higher. Scientific interpretation of such activity requires that a distinction be drawn between such actions of the sheep, dog, and horse, and the action of the man skilled in some handicraft. Reflex activity will account for breathing and walking, but only intelligent, voluntary self-direction can account for the workmanship of the artificer.

One thing more must here be remarked in order to complete the view of muscular activity in man. Under dominion of Intelligence and Will, facility in muscular action is attained, by means of which the demands of physical energy on the higher nature of man are abated, and the possibilities of intellectual action are increased. This introduces an additional element connected with manual skill. The work which has first to be done slowly, and with careful direction of the hand, and even of the separate fingers, becomes easier. So it is with the artificer, with the musician, with the artist, and in general with every one who seeks to acquire skill in manipulation. Skill means facility in doing work finely,—ease of management, and fineness of result. This possibility shows us not only the man as man acting, but the whole man coming to the best or highest type of effort attainable. It is an illustration of self-directed intelligence gaining ascendency over bodily powers. It is an example of the higher life bringing down so much of its power into the midst of the sensory and motor apparatus, and obtaining a lodgment for itself in the very midst of mechanical contrivances. Efforts once slow and irksome become rapid and delightful; aptitude becomes established in the very midst of the tissues. All such results illustrate the power of Mind over Body,—the dominion which the Will of an intelligent being is capable of establishing over a sensitive muscular system.

With this examination of muscular activity, the present division of the inquiry may be closed. Yet must it be remembered that there is a much higher range of intellectual actions than those concerned with the government of muscular power. And all these remain to present difficulties for the theory of action and reaction within the nerve system much greater than any of those encountered in course of the study of the laws of muscular activity.

CHAPTER X.

RETENTIVENESS OF ACQUISITION—MEMORY.

In treating of the uses of the sensory nerves as instruments for acquiring knowledge, it has been shown that memory is essential for experience in distinguishing successive sensations (p. 304). At the earlier stage of our inquiry, however, the simple fact of knowledge received attention rather than the increase of our acquisitions, resulting in stores of knowledge. We must now briefly consider what additional light is thrown on our activity, and the higher development of human nature, by the possibilities and laws of acquisition. From this point we carry forward with us a more complex conception of our nature. This conception now embraces all that belongs to the sensory apparatus, and to the motor apparatus of the nerve system, which is the governing power over the body; and all that belongs to Intelligence and Will power as the governing powers of a higher life, and thereby the true governing powers of the whole life.

The question which now arises is this,—How far is human life influenced by varied acquisitions? how far is the nature expanded and enriched by storing up the fruits of earlier effort? We must now regard memory not merely as a connecting band or cementing power, giving unity to a series of sensations, but a power performing an important part in the very midst of that higher life where Intelligence and Will are working out their best results. We must begin where physiological laws operate, including all phases of acquisition which come from use of the sensory and motor apparatus, but we shall end where psychological laws find application, and the higher efforts of intelligence and will supply the materials.

Reverting, for illustration, to the skill of the artificer, we are contemplating at once physical and intellectual aptitudes, and have a double phase of acquisition presented. The true *source* of his skill is the intellectual action by which the manual effort is guided. But the *form* of skill for which he is distinguished is concerned with a definite number of the nerves and muscles, in the use of which an acquired facility has been attained. Take away the intellectual action, and the entire result is wanting. Voluntary intellectual effort is the common condition for attainment of all forms of skill. Disable the muscles of the arm, and the active use of skill possessed becomes temporarily impossible; but restored muscular energy shows that the aptitude belongs to hand and fingers just as before.

In order to reach an exact theory of the laws of personal acquisition, it is needful carefully to distinguish these two features of skill. They present two distinct phases of acquisition,—the one connected with nerves and muscles, the other with intelligence and will. There is "a memory" or retentiveness in both, in accordance with which it is clear that facts point to a twofold theory of acquisition. Taking into account the relations of the higher and lower forms of action belonging to our nature, we observe a feature of retentiveness peculiar to the intelligent nature, and another belonging to the physical nature. These two can neither be identified nor separated in any explanation of dexterity in muscular effort and manipulation. I shall consider them in succession, rising from the lower to the higher, afterwards contemplating the union and harmony of the two as characteristics of one life.

There is a physical acquisition, resulting in physical aptitudes. Evidence of the familiar fact can be gathered in a multitude of forms. There is no artistic attainment which does not illustrate it. In every such case there is a real attainment, a retentiveness of something acquired. The seat of the acquisition is partly in the nerve system, partly in the muscular, and is definitely restricted to the portion of the organism concerned in the form of activity. In accordance with the fact pointed out when treating of the nerve system (p. 56), repeated use of any part of the motor apparatus leads to a gradual increase of power. Consideration of the conditions under which this increase proceeds will guide us to the laws which determine the retentiveness belonging to the nerve system, and to the muscular system as controlled by it.

Though retentiveness, in that form to which we commonly give the name of memory, is generally regarded as concerned with knowledge, it will be noticed that that to which attention is meanwhile turned is connected with activity rather than receptiveness. Accordingly, it is the motor system rather than the sensory which engages observation. It is *outflow* of energy along the lines of motor nerve and connected muscular tissue which we find leading us to a theory of retentiveness; it is not an *inflow* of knowledge. And yet this outflowing energy, with all its attendant results, is so connected with the exercise of intelligence that it will not be possible altogether to separate the two in our study of the facts. Nevertheless, we are, in the first instance, mainly concerned with a law of retentiveness found operating in connection with certain forms of muscular action. This prominence of the motor apparatus, as compared with the sensory, is important and suggestive. There is, indeed, a degree of increase in sensibility as well as in the efficiency of the motor apparatus. But the illustration of retentiveness supplied by the sensory apparatus is much more restricted, and, as I took occasion at an earlier stage to remark (p. 55), such increased sensibility, acquired and retained, involves much more than sensibility. It really much more illustrates an acquisition by means of intellectual activity.

Retentiveness as exemplified in the history of motor activity is a real physical acquisition, resulting in greatly enlarged physical aptitude. Analysis of the facts is sufficient to show that the retentiveness attributed to the motor system involves in the first aspect of it *development of power* possessed by the motor apparatus. Fully expressed, it is development for which there is natural capability, along with conservation of the fruits of such development. This illustrates the contrast between mere mechanism and vital organism. The machine remains what it was when it was constructed, tending only to deteriorate as the result of tear and wear. Living organism is so far an example of mechanism that it also wears out; but it is so superior to mere mechanism that development is the law of its existence. This law of life is characteristic of all life and in its simpler applications the law governs human life, as it does lower animal life. This law of development applies to our life from its first stage onwards until the period of physical decay is reached, when phenomena appear in human history which cannot be attributed to any other form of life known to us—a manifest decay of physical life with progress of a higher life. There is with man, as with all animals, development through a series of fixed periods. There is the embryonic period, during which from a germinal beginning life is developed in vital relation with a higher life on which its existence depends, until the maturity of embryonic life is reached, and birth into an advanced stage of existence takes place. There is the development of infant life, of childhood, and next of manhood, and thereafter a fixed period of decline, involving the contrast in human history to which reference has been made. Now, in all these successive stages of development the results are retained as essentially belonging to the life itself. If, as is very commonly proposed from a physiological standpoint, we describe the retentiveness of the physical nature as a phase of memory—and it seems to me there is a sufficient analogy to warrant the suggestion, and to afford to physiological theory the advantage which the admission implies—it must be noticed that the admission involves acknowledgment of embryonic memory, and infantile memory, as well as the memory which belongs to more advanced stages, when life develops through the periods of childhood and youth to manhood or maturity. This no doubt involves a vastly wider range of meaning for the word " memory " than has commonly been attributed to it; but as it is granted that there is acquisition and retentiveness of acquired results, we may admit a species of Physical Memory, granting at the same time that the admission must impose upon mental philosophy the requirement that it make good a radical distinction between Memory Proper and a purely physical acquisition.

Having regard to the demands for demonstration of a distinctly higher life than the physical, as these demands fall in the present division of the subject, it is of consequence to give some prominence to the lowest phases of acquisition and retentiveness. In embryonic life there is acquisition derived from the life of the mother, leading to enlarged life of the embryo. What is thus derived becomes an essential portion of the slowly unfolding life which has its fixed period of existence within the womb. When the child is born the full formed bodily life which it possesses has been derived from the maturer life of the mother. And now the child, beginning its separate existence, makes its start in life with retentiveness of all that the mother's life has communicated, that is, with definite features of life fixed for it, constituting a phase of individuality by which the child may be distinguished from other children. And here two things come under attention, which well deserve to be considered, involving not a few perplexities. These are the two correlated facts—heredity and retentiveness. A law of heredity applies to every form of living organism born into the world. This fact brings all animal life and human life as well within sweep of a common law. And in close relation with this law of heredity comes a most interesting phase of the law of retentiveness. A few references to animal life will considerably aid illustration. Earlier stages in this inquiry have shown the prominence to be assigned to the dog in treating of questions of comparative physiology, and there is no animal which more interestingly illustrates the law of heredity. Within the one species there are so many distinct orders, with marked diversities of nature, that each order carries in its history a definite contribution to the general evidence. The pointer, the retriever, the greyhound, and the collie, all illustrate this in a most definite manner. Every young dog, of whatever order, gives evidence of a retentiveness of qualities transmitted to it in the line of its descent. If then we take every phase of retentiveness as a kind of memory, the young dog in a sense embodies in its own nature a memory of its ancestors' achievements, and our modern discoveries in embryology present us with a modification of Plato's doctrine of reminiscence which Plato did not contemplate,[1] reminiscence of what has been acquired in a prior state of existence.

What is illustrated in animal life also finds illustration in human life. The child inherits from its parents certain characteristics which determine many phases of its life. The day of its birth witnesses fixed forms of existence which have been gradually developed during the embryonic stage. This young life, sensitive to surrounding influences, yet unconscious of its own being, has not only the common characteristics of the race, but inherited specialities which mark its parentage. This is the earliest stage of retentiveness. And this is followed by another stage in which the same law applies. The progress of infant life is progress in development, connected with which there is further exemplification of the retentiveness which belongs to organism. What is acquired in course of development is retained. A stage further in advance we have the tokens of the opening of a higher life, aided not merely by sight, and smell, and touch, but by discrimination and inference, and aided by language, conveying instruction to a nature fitted to receive and retain it. Here we find evidence of a higher phase of memory, a retentiveness of a new order, which has as a distinctive feature an imperfection in the retentive power nowhere found in animal tissue. Now, in contrast with earlier stages, things acquired in the course of development are not invariably retained. Retentiveness takes place under a new law. As it passes into a new and higher phase it becomes a more difficult exercise—indeed a new exercise, introducing a higher law of progress than appears in lower orders, or at lower stages in human existence itself. There is now a process adapted for retention, under "laws of memory," which can be recognised by us as applicable in the case, by voluntary compliance with which we can acquire knowledge, adding to stores already in our possession. The true significance of this new phase of retentiveness is seen by reference both to the *difficulty* and the *facility* of retaining knowledge.

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[1] *Meno*, 86.

There is in this case a *difficulty* in acquiring which needs to be encountered and mastered. Lower forms of acquisition proceed according to a law which simply illustrates spontaneous development under favourable external conditions. There is acquisition without choice, and without any effort save what is common to all animal life from birth, in the reception of food, with the amount of sensory and motor activity involved in the search for it. But in the higher phase of activity now under consideration it is a new order of food which is sought,—

food for a higher life,—and the conditions of acquisition and retention are changed. Besides, these new conditions or laws apply to a much more advanced stage in the course of activity. There is here a marked contrast between the activity of animal life in obtaining food,—a form of acquisition which affords the key to the greater amount of all animal activity,—and the action of a higher life appropriate to the acquisition of food for its own sustenance and satisfaction. In the animal economy, if the food only be found and appropriated, the process of assimilation goes on spontaneously by chemical action within the organism, and all that is received is retained, save inappropriate material, which is separated and carried off. But the action of the higher life proceeds according to laws entirely different. To acquire knowledge and to acquire food do indeed involve to a certain point analogous effort, search, and appropriation. Retentiveness in the two cases differs so thoroughly that in the one case it implies effort, in the other no effort. The two characteristics are illustrated in human life, the one by mental life, the other by animal. In the higher, retentiveness requires personal effort; in the lower, retentiveness is inevitable, unless there be some derangement of health,—some disturbance of natural action of the vital organs. The contrast is notorious and familiar from the very earliest stages of education in the life of a child. Lessons in the alphabet introduce a marked distinction between the hour for instruction and the hour for dinner. There are, indeed, in the history of the lower animals examples of difficulty in acquiring and retaining. But these are not connected with the life in its natural state. It is not in running, or leaping, or gamboling, or eating that any difficulty is experienced. But if you would train a dog to ring a bell, lift a latch, or walk on its hind legs in a semi-erect posture, the thing can be accomplished only by slow, irksome, and repeated efforts. These things will not be attempted by the dog spontaneously. The design must come from without, and the determinations to continue the effort must also come on each occasion from beyond the ordinary range of organic impulses. The difficulty comes from want of anatomical adaptation for the work to be done, and the want of natural impulse to its execution. If the effort be sufficiently long continued there is in the nerve and muscular system a law of retentiveness which will induce greater aptness, or, we should rather say, diminish the awkwardness and disagreeableness experienced by the dog in walking on the two hind legs. There is a law of retentiveness in every living organism which provides for as much as this, so that training to do what is unnatural is a possible thing under our management of the lower animals. But when the singular movement has been acquired, the dog does not spontaneously take to the exercise. However long we keep on with the training, the animal does not itself begin practising. If it be left to itself, by neglect of practice it soon loses the accomplishment. But the difficulty of men in acquiring knowledge is of a quite different order. There is nothing constrained and unnatural in the effort. But there is a new order of law introduced, and the distinctive feature in the case is that we must voluntarily apply the law—that is, we must recognise the law as the condition of attainment, and must apply it with the special end in view. Take the two familiar laws of Memory,—attention and repetition; and the distinction between mental action and the action of nerve and muscle is at once apparent. That distinction is all the more striking that there is an application in a modified and restricted sense of both attention and repetition in training an animal. Whoever would train an animal to such acquirement as that described must command its attention, and constrain it to repeat the irksome effort. There is enough analogy between these facts and those of child life to account for less or more of similar constraint employed in the earlier stages of human life. But effort here is soon aided by intellectual interest or curiosity, which seeks for gratification in the direction in which the teacher is guiding. The sight of a class of children under the management of a competent teacher sufficiently illustrates this. It is indeed true, whatever interest be thrown around the subject taught, that learning is a task, and tasking any power, bodily or mental, implies effort, and effort may become irksome. But the essential difference between the animal and the child in meeting the demand for effort, is that the one does not voluntarily take to the task, whereas the other does voluntarily apply the law of attention and repetition. Learning is a self-discipline. There is deliberate concentration on the subject, and return over the ground, in order to make sure that the lesson has been acquired. When this has been done, something entirely different is accomplished from establishing facility in nerve action, and aptness in muscular activity. A broad line of demarcation separates the mode in which skill is acquired in the gymnasium, from that by which knowledge is acquired in the school. The two things are not on the same line. Knowledge of geography is not an attainment only a little further on than gymnastic exercise. The physical exercise may, indeed, contribute to the readiness and energy with which one takes to mental effort. But it is the contribution of an auxiliary, playing a very subordinate part, when a new and higher power comes into action. Contrast appears in this, that all through life a definite amount of physical exercise must be taken, along with persistent and concentrated study. But the one involves no progress, the other implies advance to heights of attainment not even within sight of the student at the earlier stages of life. Physical exercise may be continued until the effects of failing physical energy are very apparent; and at the very same period of life intellectual acquirements may be accumulated and retained more rapidly than before. There is an illustration of voluntary determination on both lines. Even when there is less aptness for physical exercise, it is continued, because of the importance which the student assigns to the laws of physical health; and even with the consciousness of greater aptness for acquisition of knowledge, and greater delight in it, there is still voluntary concentration, and exercise of mind dwelling upon the phases and relations of facts brought under attention. There is voluntary application of the laws of attention and repetition, that there may be retention, reproduction, and representation of the acquired knowledge, in accordance with the threefold aspect of memory admirably brought out in the analysis of Sir William Hamilton.[1]

A stronger light still is thrown upon the distinction between the retentiveness belonging to vital tissue and that which is connected with intellectual exercise, when we notice the contrasts between the two forms of *facility*. Skill in execution, and facility in acquiring fresh knowledge, amply illustrate the difference. Facility of manipulation becomes fixed in the muscles, nerve fibres, and nerve cells. The right hand has acquired a cunning so marked, that you cannot witness the first movements of the hand on the part of a skilled performer on a musical instrument, or of one who has skill in the use of any implement, without noticing that the muscular movements indicate aptness belonging to the tissue itself. The preliminary run of the right hand over the key-board of a piano, before the performer begins in earnest the piece of music to be performed, is an indication of a muscular sensibility connected with the use of the acquired skill. So certainly is there facility of a nervo-muscular type that many of these acquired actions can be done quite readily by a person while asleep. The law of mental acquisition applies in the opposite direction. Facility in acquiring knowledge diminishes the effort, but does not abate the demand on attention. The performer at the piano, or the artist working at some portion of his picture, may speak with you on some subject quite apart from his more immediate engagement. But the person busy acquiring a language, or seeking to lodge in his mind minute details of scientific classification, cannot do this. Hence also the difference in after use of what has been acquired. The skilful performer or experienced artist wants only his key-board before him, or his brush in hand, in order to put into exercise a facility of manipulation which he cannot explain. But if one want to recall a word which has escaped his memory, or a poetic passage, or a scientific distinction, it is altogether otherwise. The possession is not stirring at the tips of the fingers, or moving among the nerve cells eager for egress. The laws of association, accepted universally as laws of memory, imply the contrary, for they can be used to aid us in a search, which, after some time and effort, will help us to alight on the possession we want to recall for immediate use. There is nothing in the working of vital tissue at all analogous to this. These laws of association are so powerful that, within the realm of mind, they are sufficient to account for involuntary recollections, but they are primarily and essentially instruments for the use of a voluntary intelligence. Things similar, things dissimilar, and things contiguous or brought into affinity, become so connected in our intelligence, that they tend to suggest each other.[1] What then is involved in the application of these laws? Voluntary intellectual exercise, and that carried with deliberation and care into minute details. There is observation of resemblances, of differences, and of relations as an introductory requirement before these laws of association can become to any great extent influential in the history of mind. The extent to which this prerequisite, in the form of intellectual discrimination, has been carried, makes all the difference between individuals in respect of the stores of knowledge they possess, and accounts for the pre-eminence which belongs in this region to the man of science.

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[1] *Metaphysics*, vol. ii. p. 205.

Professor Bain has ventured upon a hypothesis as to retentiveness of our knowledge in the substance of the brain itself. He suggests "the possibility of storing up in three pounds' weight of a fatty and albuminous tissue done into fine threads and corpuscles, all those complicated groupings that make our natural and acquired aptitudes and all our knowledge."[2] What has just been said affords materials for testing such a hypothesis. Most important for this purpose is the broad contrast between physical aptitudes and retention of knowledge in accordance with laws of a character quite different from those which determine results in the nerve and muscular system.

The most important part in the hypothesis is contained in the following statement, that "renewed feeling occupies the very same parts, and in the same manner as the original feeling, and no other parts, nor in any other manner that can be assigned." It is an interesting and not improbable suggestion that this may be true in the history of brain action, in so far as impressions on brain through the sensory apparatus are concerned. I incline to think the hypothesis in this restricted form highly probable. But everything which makes it probable in connection with the recalling of sensations, seems to me to make it improbable as bearing upon the more advanced forms of intellectual exercise. Since sensibility at the periphery implies movement of the nerve cell, it seems not at all unlikely, that when a particular sensation of colour, or light, or heat, or sound is remembered, some distinct movement of the nerve cell belonging to the sensory nerve concerned may take place. This is supported by well-known facts as to the power of the imagination in acting upon the nerve system, inducing agitation which has no external explanation. It is quite supposable, and in keeping with such analogy, that the recollection is aided, and in part sustained, by movement in the appropriate nerve cell. But this does not account for *the fact of recollection.* Let us suppose that when a man recalls a sensation of sweetness, there is in the brain some movement in the cellular matter related to the sensory fibres coming from the tongue and palate. The manner in which the organs of taste can be affected, so as to act upon the salivary gland, even by the imagination alone when directed upon favourite articles of food, lends considerable support to this view. But the essential question is,—What accounts for the fact of recollection? Whenever the organism is acted upon from without, as by the sight of ripe fruit or other article pleasing to the palate, it is comparatively easy to find the explanation. The impression made on the optic nerve may, by established coordination within the brain, act upon the sensory cells connected with the fibres coming from the mouth, and the movement so induced may be propagated along the connected fibres, producing that result known to us as "teeth-watering," and which may be not unreasonably described as a reminiscence of taste. If a fresh sensory impression in any degree stir the cells belonging to the sensory apparatus, we have in the new impression what accounts for the rise of recollection. But if there be no impulse from without, how shall we explain the fact of recollection? It cannot be maintained that all recollection is connected with new sensory impression. Nothing is more obviously within our reach than the power of devoting ourselves to the exercise of recalling the scenes and events of early life. When so occupied, a person is readily charged with "absent-mindedness," and his look conveys the impression of remoteness from present influences. This exercise of recollection may, indeed, be involuntarily started; but it may be voluntarily and quite deliberately undertaken, and this fact is unexplained by the hypothesis. Again, it cannot be alleged that the brain spontaneously begins to vibrate, so as to throw a series of cells into excitement; and that these cells, ringing changes upon once familiar combinations, keep us in a tumult of recollections. There are, indeed, recollections which may be said to haunt the brain, and which gain a mastery over the individual; but such experience is unusual, and for the most part abnormal. Human experience is not thus at the mercy of recollection. Even if the nerve cell be vibrating while we recall a particular sensation, what starts this vibration? If we are to follow the analogy afforded by the nerve system, we may say that as with the original impression the impulse came from without, the revived impression must, in absence of external influence, depend upon an impulse coming from within. Professor Bain forcibly states his case in the following sentences:—"If we suppose the sound of a bell striking the ear, and then ceasing, there is a certain continuing impression of a feebler kind, the idea or memory of the note of the bell; and it would take some very good reason to deter us from the obvious inference that the continuing impression is the persisting (though reduced) nerve-currents aroused by the original shock. And if that be so with ideas surviving their originals, the same is likely to be the case with ideas resuscitated from the past—the remembrance of a former sound of the bell." The suggestion is admirably put, though it seems unwarrantable to speak of the "continuing impression" which attends on the gradual cessation of the current as "an idea or memory" of that of which it is still a part,—a continuance. What is wanted is to account for the fact of the revival of the impression, and this is not done. If sensations are "resuscitated from the past," we need to ascertain how such resuscitation takes place; and it does not help us towards an explanation even if we allow that "the renewed feeling occupies the very same parts, and in the same manner as the original feeling."

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[1] Hamilton's *Metaphysics*, vol. ii. p. 233. Mill's *Examination of Hamilton's Philosophy*, p. 219.

[2] *Mind and Body*, p. 89.

There is, besides, an inconsistency in supposing that a nerve cell, or any number of such cells conjointly, can be not only the seat of the renewed impression, but also can exercise both a retentive power preserving some record of the past impression, and a reproductive power bringing it back to consciousness. This difficulty is greatly increased if, while such functions are attributed to a cell, it may in the interim be occupied with other impressions. Previous investigations show that repeated exercise of the same sensory or motor combinations, under voluntary direction, will secure facility of exercise. A certain impression is made on the tissue, which shows itself by the subsequent facility in acting. But this facility is the result of a continuous influence to which each successive instance of voluntary use of the apparatus contributes. The result is not a separate and separable record of single acts, but a cumulative result, in which the quota contributed by each action or vibration of the apparatus is indistinguishable. We may not unreasonably describe this as a kind of memory belonging to living organism, for it holds good of animal tissue even where the guidance of will comes into play. But there is in these facts nothing analogous to what is here suggested; nothing of that form of exercise which is required of a memory retentive of distinct acts, afterward to be recalled as distinct. If, in addition, we must suppose either that the nerve cells retain such a record of a past impression, and all the while continue functionally active in the reception of fresh currents; or that the nerve fibre, after having acted upon one cell, selects another from those still unoccupied, and so continues encroaching on an available number of cells assigned to each sensory nerve, the complications of the hypothesis become serious. Each alternative is beset by its own perplexities, which seem to me fatal to its claims. The first is clearly untenable. No single cell or small group of correlated cells, connected with a single sensory fibre, could keep on receiving fresh impressions sent along the fibre, and also retain some record of those which have gone before. The only feasible alternative is the second, and to that accordingly Professor Bain gives the preference. But the demand thereby made on cellular tissue transcends available area to a degree far beyond what can be reckoned on the most favourable supposition. There are very great difficulties in the way of supposing that either the cerebrum, or that portion of it not concerned with motor activity is, in addition to all its other functions, a storehouse of sensory impressions. We have seen what a vast amount of work the brain has to do in providing for the sensori-motor activity which is its primary function. Every portion of the surface of the body has to be maintained in a sensitive condition; nerve currents have to be received from all parts; correlated action has to be propagated between each sensory cell and a variety of motor centres, by means of additional apparatus suitable for this work; and nerve currents have to be directed through any or all of the motor nerves, in order to act upon the muscles, at the behest of the will. Even if we claim no portion of the cerebrum for purely intellectual action, and so considerably abate the difficulties for a theory of cellular retention, it is difficult to imagine fulfilment of the assumed functions. When further we deduct from the general bulk of brain the whole mass of nerve fibre in the centre, which is conducting fibre, requisite for the ingress and egress of nerve currents, we seem to be working with an impossible hypothesis. If every bell which sounds, and every musical note we hear, and every word spoken to us, and every object seen by us, and every act of tasting, and every sense of odour, and every excitation of tactile fibres, lodges an abiding impression on the cellular tissue, we must accept a "honeycomb" theory inconsistent with the known laws of brain action, implying as they do fresh activity and easy renewal of effort from time to time in the same apparatus, as fresh nourishment and rest are obtained. The known laws of cerebral activity do not favour such calculations as are suggested by Professor Bain. The space appropriated for the sensory and motor functions includes a great part of the mass of cellular tissue. Besides, if we agree to deduct the vast range of intellectual operations, assigning them to a higher nature, we still need distinct local provision for all the forms of control over the organism requisite for intelligent regulation of physical activity. We still ask provision for such sensory and motor activity as may be required for external observation, use of language, and organic aids connected with memory, already named as accompaniments of our ordinary thought. Without deduction for these demands, Professor Bain proceeds to estimate the probable number of acquisitions, and the space available for them. Reckoning upon the whole area, he says: "With a total of 50,000 Acquisitions of the assumed types, evenly spread over the whole of the hemispheres, there would be for each nervous grouping at the rate of 20,000 cells, and 100,000 fibres. With a total of 200,000 Acquisitions of the assumed types, which would certainly include the most retentive and most richly endowed minds, there would be for each nervous grouping 5000 cells and 25,000 fibres."[1] In this calculation the fibres, as connecting tissue, may be kept out of account, except as representing an acquired facility in acting. The calculation as to cells must, I think, be greatly modified, the figures representing cells being greatly reduced, and those representing Acquisitions greatly increased. On the one side, it is impossible to proceed upon a calculation that apportions the whole cellular substance for retention. On the other, if retentiveness be a function of the cellular tissue connected with all nerve activity, the extent to which the nerve tracts are in use every day is such, that 50,000 would be reckoned in the course of a few months of an ordinarily active life. It may be that 200,000 acquisitions is a number sufficiently large to embrace the whole acquirements of the best endowed minds,—we are really without data to guide us here, —but it would not nearly represent the number of nerve vibrations bringing the apparatus into action. If we reckon *words* alone, without counting the thousands of sensory impressions experienced daily, Mr. G. P. Marsh says that "the number of English words not yet obsolete, but found in good authors, . . . does not probably fall short of one hundred thousand."[2] These are not used by any one man. Shakespeare is reckoned to have used 15,000 words,—Milton, in his poetical works alone, 8000; but these do not include the inflections of the same root.[3] What shall we make, however, of a case like that of Cardinal Mezzofanti, who spoke fluently thirty languages?[4] Professor Bain, in estimating the demands made on the cellular mass in the cerebrum, assuming "an independent nervous track for each separate acquisition," has not allowed sufficiently for his subsequent statement in the following sentences:—"It is not at all likely, however, that the entire brain can be portioned equally among the various subjects to be remembered or acquired. Besides the fact that a great part of the brain substance exists for mere battery power —to propel muscles, and to keep up energetic volitions and manifestations of feeling—there seems often to be a duplication of the same embodiment in different parts.[1] The two hemispheres apparently repeat one another; when one is injured, the other keeps up the trains of memory, although with weakened energies. It is even supposed that in the same hemisphere there may be duplicates, since injuries in the forepart of the head have occurred without destroying any single class of acquisitions."[2] The grounds on which such acknowledgments rest have been already presented. But important as these statements are, Professor Bain has not prepared a modification of the figures in harmony with the admissions. When the calculations have been adjusted, it will, I apprehend, appear plain that there does not exist in the cerebrum cellular substance sufficient to support a hypothesis that there is "an independent nervous tract for each separate acquisition." Under the hypothesis, it is impossible to restrict or select the sensory impressions to be stored in the brain. If the retaining of impressions is the result of functional activity, it follows that every act of the sensory apparatus must find a nerve cell within which to lodge a distinct and separate impression. This appropriation of nerve cells becomes needful for renewal or recalling of sensory experience, in order that the cellular activity may occupy "the very same parts, and in the same manner as the original feeling." On the conditions implied, there is no possibility of limiting the number of impressions to be retained, and so inquiry passes over to the available number of cells, whither, indeed, Professor Bain directly conducts it. Allowance must, no doubt, be made for diversities in the power of impression, and thus some place may be found for a theory of organic "forgetfulness." A faint impression must produce a slighter effect on the cellular tissue than a vivid and powerful one. But the benefit thus accruing to the hypothesis on the one side is more than balanced by disadvantage on the other. On the supposition before us, it would naturally follow that louder sounds should be more effectually retained, by making a more distinct impression on the nerve cells, than fainter sounds. But if we refer for illustration to the words we hear, we find it often otherwise. Words uttered in a subdued tone, or even in a whisper, are better remembered by us than many words uttered with great volume of sound. The law of retention in such a case is the reverse of what it should be, if it were provided for by mechanical action of the sensory apparatus. If a public speaker in the midst of an animated discourse, were gradually to slow his rate of utterance, soften his tones, and with all appearance of strong personal conviction, utter some warning with subdued voice, that passage would be remembered more vividly than many others which have been declaimed with animation, and great power of voice. The deeper impression is dependent partly on sensibility, partly on intelligence; and the latter is the determining power as to memory. The law of contrast does, indeed, apply in the region of sensibility. For if "change of impression is necessary to our being conscious,"[1] a very marked change, as from loud and rapid utterance to a slow subdued expression, is clearly marked as something new, and arrests attention on that account. It is narrated of a preacher who observed a considerable number of persons in his audience fast asleep, that he suddenly paused, and, having remained silent for some minutes, he had the satisfaction of seeing all the sleepers wake up to ascertain what had happened. There is not a very high exercise of intelligence in such waking; it is apt to be a dawning intelligence, but it illustrates the fact that there may be an impression from the very want of sensory impression, observational power which takes account of contrasts. It is intelligence in the hearers which mainly accounts for specially vivid recollection of a passage delivered in slow and subdued tones. But should the public speaker resort to such a mode of address for utterance of a commonplace, the law of recollection is so far from being satisfied, that there will be no such aptness in recalling the utterance, as otherwise would have been experienced. Intelligence is the key to memory; while sensibility is the key to any retentiveness in tissue. There is thus a broad contrast between two distinct phases of retentiveness, each depending upon the application of different laws. There is a memory which is entirely dependent on discrimination and laws of association. Towards the explanation of this the activity of sensory apparatus contributes only a small share. There is a "memory" dependent on the simple activity and sensibility of tissue, quite apart from intelligent discrimination, under purely mechanical law. So far as mere retentiveness is concerned, the physiological explanation of this is complete. If we restrict attention exclusively to the latter, we enormously reduce the demand upon the storing room which the brain affords, and so add considerably to the probabilities in favour of Professor Bain's theory; but we do so by holding completely in reserve all the main characteristics of memory as commonly exercised by man. Even with this sweeping restriction, however, I doubt if retentiveness of nerve tissue, which is admittedly a fact, can receive such breadth of interpretation as to warrant us in regarding it as a uniform and constant law of nerve action. It is an interesting and valuable suggestion that when we recall a sensory impression, there is awakened some vibration in the very same part of the tissue as was originally thrown into action by the impulse sent from the periphery. But it is a much more perplexing and less fruitful suggestion that the normal action of a sensory cell involves retentiveness of impression, and that this retentiveness is adequate to the task of reviving the feeling. The whole body of ascertained truth included under the physiology of the nerve system is against the supposition. The utmost which ascertained results warrant is increased facility of action within the nerve system, and an increased sensibility to sensory impulse, which increases the power of external impulse. In this way local associations, distinct from the organism, and standing at the opposite extreme from the "laws of association," requiring an exercise of intelligence for their application, act upon an increasingly sensitive organism and present facts closely analogous to those of memory proper. Illustrations are so numerous and familiar that I need not dwell upon them. Whether this will account for the manifestations of memory in the lower animals is not quite clear. So far as my observations have gone, I incline to think it does; though I have several times considered the results perplexing. Even a blind horse becomes familiar with the road frequently travelled over. One of the most striking facts I have observed in this relation is afforded by a cat which has been for ten years a favourite in the family circle. It is accustomed to lie on the hearth-rug, sleeping in front of the fire. At the same hour each evening it is lifted, and carried away to its quarters for the night. Often when the door is opened, and it is approached at this hour, and while the person is still some paces off, a slight tremor is seen to pass over its body, and the animal wakes, lifting up its head, and giving a slight purr, as the hand is stretched towards it. The opening of the door has seemingly something to do with it; but I notice also a slight vibration of the floor. These impressions, however, produce no effect at any other hour of the day. This is much more striking than appears with the dog, which is simply called, and ready to run at once. But in his case, the slightest sound produced by opening or closing the biscuit-box makes him prick up his ears. When the family are seated at table, it is not uncommon to shut the lid cautiously, in order to avoid noise, and it is astonishing how slight a sound will arouse him from sleep. This cautious closing of the lid is in accordance with the tactics adopted by the shepherds in a southern county of Scotland, who sat still in church while the benediction was being pronounced, thereby "cheating the dogs," and preserving decorum, by delaying the sudden stretching of the limbs and scampering along the lobbies. From such cases it seems fair to conclude that nerve sensibility goes far to account for manifestations of "memory" in the lower animals. In almost all the examples mentioned, external influences clearly contribute a part, by acting upon the sensory apparatus at the time when revived feeling is apparent.

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[1] *Mind and Body*, p. 107.

[2] *Lects. on the English Language*, p. 181.

[3] Professor Masson's *Essay on Milton's English,—Milton's Poetical Works*, I. ix.

[4] See *infra*, p. 389.

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[1] For evidence of this, see above, p. 110.

[2] *Ib.* p. 108.

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[1] *Mind and Body*, p. 43.

Increased sensibility, by frequent use of the same nerve tracts, and a phase of retentiveness harmonising with the nature of the organism, are clearly established facts. They seem, however, to lead no further than to the conclusion of increased facility in cells and fibres, without contributing anything towards a theory of particular memory.

There still remains, however, even on this theory, the one essential point, How does resuscitation take place? If it be at the bidding of external impression, the nerve apparatus may be competent for the work to be done, that being to rouse a form of cellular activity. But there is nothing in the normal action of the nerve system which fits it for originating sensory activity within its own substance. The sensory cell is not self-acting; it does not of itself originate sensation. It is indeed possible that an excited and abnormal condition of a sensory portion of the cellular tissue might awaken what *we should regard as* equivalent to sensation. But this does not favour the view that the sensory cell is a self-acting agent. And if it be not, we need, in default of impulse from without, impulse from an inner sphere of experience, where intellectual activity proceeds under laws quite different from those which apply in connection with purely sensory action.

Thus in attempting to account for the facts of memory, familiar from early life, we pass the boundary into *the region where intelligent discrimination is a first requisite for remembering.* Within this region the laws of association require intelligence as essential for their application. Under these conditions we exercise a particular memory or power of recalling the exact combinations formerly recognised. There is indeed here, as in the region where tissue alone operates, an acquired facility, a facility in retaining, recalling, and representing things past; but in this case facility is attained only on condition of voluntary exercise of intelligence perseveringly repeated. The effort to recollect gradually becomes less difficult, the task less irksome, and a pleasure is experienced in the use of the gradually developed power. Thus the painfulness of the task assigned in early life when memory-work is imposed by authority disappears, and man uses his memory as an important auxiliary in the sphere of intelligence. The bond of union established by an exercise of intelligence may become so strong as to lead to spontaneous recollection. But so much is this power of Memory under voluntary control, that we voluntarily recall combined scenes and thoughts. Practice in this department may be carried so far as to enable a speaker to retain, and call up as required, a lengthened discourse. And a still more striking example of the power of will in this matter is shown by the fact that we may set ourselves to banish from our memory what we feel it a duty to forget. The task is difficult and irksome, requiring a higher degree of self-control than our early efforts at recollection, and it is attended by repeated sense of failure. But there is a possible victory,—not by mere inaction of the memory, but by conflict with spontaneous activity of memory, and reconstruction of a new class of associations, which shall take the place of those dislodged. Mental associations are not indissoluble. The power which constructs can break up the union. But a voluntary forgetfulness is possible only by voluntary construction of new associations under guidance of intelligence.

Recollection *following upon* intelligent discrimination is an essential characteristic of our experience. Such a power being established, as distinct from acquired facilities of nerve action, its importance as providing for attainment, and thereby for the unfolding of a higher intellectual life, must be obvious. If memory is needful for the simplest acts of discrimination as we mark the points of contrast between successive sensations,[1] in a higher region of attainment, and at a point more advanced in the history of mind, it becomes an essential requisite for the development of our nature. It is by aid of this power of Memory, storing up our acquirements as our study is continued, recalling the lessons of a past experience as enabling us to profit by past blunders, and making it possible for us to form a conception of our entire life as a unity, that Intelligence and Will reach those heights of attainment which raise man immeasurably above the possibilities of mere animal life. On this aspect of the problem, Professor Hermann Lotze has written with great clearness and force. After urging that in man's life there is "freedom from the compulsion of mere mechanical order," and a consequent impossibility of comparing physical and mental processes, he says:—" As the decisive fact of experience which compels us in the explanation of spiritual life (*des geistigen Lebens*) to affirm in place of mere matter a supersensuous being as the subject of the phenomena, we must mark the unity of consciousness, without which the sum of our inner conditions could not become the object of Self-observation."[1] A knowledge of Personality we have, by simple contrast of sensations; a knowledge of Personal Identity, only by that higher exercise of Memory belonging to an intelligent nature recognising the unity of our being through widely separated periods of existence.

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[1] See above, p. 122.

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[1] *Mikrokosmus*, i. 170.

CHAPTER XI.

USE OF SPEECH.

We have now seen that personality, known to each individual as the essential characteristic of his own life, is self-conscious, self-directed Intelligence. We have further seen that the knowledge of personal identity is knowledge of the unity of personal experience, as we recall events in our own life, and manifold stores of knowledge accumulated during past years. Personality is thus the central feature of human life, in accordance with which each member of the race regards himself as a distinct being, possessed of powers all his own, and hedged round by obligations which he must respect, and which none but himself can fulfil; having within himself the government not only of the organism which he calls his own, but also of his life as a whole, so as to determine what it shall be under the discipline of events.

Having dealt with our acquisitions, both organic and intellectual, I proceed now to contemplate Speech as an additional fact prominent among the distinguishing features of human life. If a Memory, operating within the sphere of Intelligence, enables us to store up our acquisitions, the power of Speech, at command of intelligence, provides not only for the outflow and natural use of our acquisitions in influencing others, but gives us the signal advantage of being quickened by their thoughts, as organism cannot be quickened by other individual organisms of the same species.

A power of vocalising, very restricted in its range, does indeed belong to the lower animals, and affords a natural subject of consideration by way of introduction to this branch of the main question. Each animal possessed of this power emits its own special cry, and is capable of giving forth some gradation of sound, the varieties in which are recognisable by others of the same species, producing, when heard, an effect analogous to that which has occasioned their expression. This restricted range of vocalisation is adapted to indications of fondness, fear, and pain. There is commonly some form of sound employed by animals expressive of fondness between male and female, and between mother and her young. The mother commonly calls for her young, and the young call for their mother. There is besides an expression of fear at sight of danger, which serves as a warning to those of the same species which are near. Considering how constantly one race of animals preys upon a lower order, this use of vocalising power fulfils, to a very large degree, a protective function. There is besides, the more acute and convulsive cry of pain, such as is uttered by the animal which has fallen a victim to its captor. All these forms of expression are connected with the exigencies of animal life. They all depend on organic sensibility, excited either by organic actions or by external influences. In the case of the ewe, increased milk supply may incline her to seek her lamb, as the sense of hunger may incline the lamb to seek the mother. In either case, the familiar bleating expresses organic feeling, and is much more frequent when organic restlessness is induced, as by separation of the lambs from their mothers. The expression of fear is a direct result of impression made upon the organism, as has been shown by experiments on rats, which are seen to spring forward on each occasion of the utterance of a slight sound in imitation of the movement of a cat. The cry of pain is the uniform expression of the sense of acute suffering when injury is inflicted on the organism. It is thus clear that in all these cases we have examples of reflex action of the nerve system by means of fibres connected with organs of vocalisation. There are powers of vocalisation which are acted upon by sensory stimuli, as we have seen that on application of the electrode to No. 9 on the brain of the dog (see p. 103), the animal, though under chloroform, will be heard to bark. Under ordinary conditions, such vocalisation must, therefore, be reckoned as illustrating reflex activity.

Now, a child has this spontaneous power of vocalising. Attainment is not needful here, and is not aimed at as any part of the child's training. Experiencing satisfaction or craving, the infant gives forth the sound natural to it. According as it is actively employed with sense of satisfaction in the exercise, or uneasy in its performance, it will be heard crowing or crying. This in the early stage of human life is exactly analogous to animal life. But when we come to consider articulate utterance, we have something distinctive of man, for which we need a higher explanation. The line of separation is reached when discrimination begins, as a fact altogether in advance of sensibility. *Articulate utterance is the expression of intelligent discrimination*, not merely of diversity of sensible experience under organic stimuli. If there be speech which is the exponent of reflection, its use, regarded merely as a physical manifestation of an inward reality, becomes a distinct testimony in proof of the existence of a rational nature, acting in accordance with laws distinct from those of organism. As Kussmaul has said in his elaborate dissertation on *Disturbances of Speech*, distinguishing between physical and psychical or mental, "It is self-evident that psychical (mental) activity must exist wherever sensations are perceived, and judgments are arrived at."[1] Accordingly, the language which expresses discrimination and judgment is a testimony for mind, and, as it affords an index of mental procedure, the study of language may become a medium for the study of mind, as implied in comparative philology. This truth has been amply illustrated by Professor Max Müller.[2]

In treating here of the use of language, it is needful in the first instance to have regard to the physical contrivances which make articulation possible,—what has been called "the mechanism of speech." It is by the management of the larynx, tongue, and lips, that articulation is accomplished. The tongue is a muscular structure capable of varied and delicate movements; and in the larynx there are exquisite muscular arrangements regulating the movements of the vocal cords. When a high note is to be sung these cords are brought up to extreme tension, leaving but a slight aperture for the emission of sound. When the singer draws a slight breath the cords are somewhat relaxed, and the opening proportionally enlarged. When a long breath is drawn the cords are still further relaxed, and a much wider opening is provided for the reception of air. The organs of articulation are connected with the nerve centre by a variety of tracts, and the nerve fibres concerned are numerous and complicated; but their distribution to the several ganglia, and portions of the cerebrum, is still matter of very great perplexity. There is, however, a sufficient amount of agreement to admit of a general statement that the medulla oblongata, the basal ganglia, the cerebellum, and the portion of the frontal lobe of the cerebrum next the fissure of Sylvius are all concerned in some degree in the control of the organs of speech.[1] Kussmaul states the facts in the following sentences:—"For the purposes of speech there exists an apparatus as vast as it is complicated, consisting of nervous tracts and ganglionic centres, which partly occupy the position of the loftiest workshops of the conscious intelligence and of the will, and are partly reflex agencies, in which simple and ordered sensory stimuli are converted into motion. Such a thing as a simple 'centre of language,' or 'seat of speech,' does not exist in the brain any more than a 'seat of the soul' in a simple centre. The central organ of speech is, on the contrary, rather composed of a large number of ganglionic apparatuses, widely separated from one another, but connected by numerous tracts, and fulfilling certain intellectual, sensory, and motor functions."[2] Kussmaul inclines to localise intellectual functions in the brain. Hence the references to the "workshops" of intelligence and will, and to ganglia fulfilling "intellectual functions," adopted on purely analogical grounds.

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[1] Ziemssen's *Cyclopædia of the Practice of Medicine*, "Diseases of the Nervous System," (*Translation*,) vol. xiv. p. 692.

[2] *Science of Language*, 2 vols. *Vide* Geiger's *Ursprung und Entwickelung der menschlichen Sprache und Vernunft.*

Having regard meanwhile, however, to the "mechanism of speech" alone, and holding in reserve the higher questions concerning the manner in which speech is directed for intelligent ends, it is clear that the apparatus which provides for articulate speech must be very complex in structure and arrangement. There is a considerable range of motor acquisition, in connection with which the senses of sight and hearing have much to do before the higher uses of speech are possible. From this point of view, Speech presents a phase of acquisition similar to the first or lower class of acquisitions discussed in the previous chapter. And it is only after this preliminary stage has been passed that the higher uses of speech come into view, providing for a new and greatly higher form of acquisition, and a still more advanced exercise connected with communication of thought.

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[1] See Broca, *Sur le Siége de la Faculté du Langage Articulé*; Kussmaul, *Disturbances of Speech*, as above; Bateman *On Aphasia*; Ferrier's *Functions of the Brain*, and his *Localisation of Cerebral Disease*.

[2] *Cyclopædia of the Practice of Medicine*, Ziemssen, vol. xiv. p. 614.

The motor acquisitions requisite for a free use of speech are many. The nerve action needed for their attainment and coordination is necessarily complex, and the apparatus must be brought into regular use, in order to make language an instrument available for intellectual purposes. This subordinate and preliminary work for acquiring facility in vocal exercise belongs to the early stages of an intelligent life, and is largely concerned with skilful use of suitable apparatus. How the physical appliances are placed under personal regulation is no part of the knowledge requisite for bringing the vocal organs into action. Practice is possible, and it is the essential condition for attainment. In its earliest stages such practice is largely an imitative exercise. Personal effort advances by the aid which is afforded through observation of others. When in this connection we say that imitative tendency is strong in a child, we mean that the child *observes* what his seniors do, and *tries* to do in like manner. This is something quite different from the spontaneous crowing or crying of infancy,—something quite apart from the expression of fondness, fear, or pain coming from the higher orders of animals,—and something quite in advance of the imitative tendency shown by a few of the animals. The boundary which separates the two first-named classes of facts from those connected with acquirement of language is broad and very conspicuous. The expressions of the infant and of the higher animals, which, notwithstanding interesting differences, may be classed together, are accounted for by sensory stimuli. Impressions on the sensory nerves act upon motor apparatus. This is the whole explanation. But when the child, passing out of the stage of infancy, begins not only to observe, but so far to concentrate observation as to notice what others are doing, and in consequence attempts imitation, we need further explanation. It is true that even in this case the child is not separated from sensory stimulus, but this influence is not sufficient. There is *work done* in a higher sense than when a lamb bleats, or when a rabbit starts away, and a hare crouches in its lair at the sound of a footstep. Here a further contrast between child life and merely animal life meets us. Some animals have imitative tendency as well as man, and it becomes needful to remark that animal imitativeness, and that of a child, as exemplified by use of speech, are quite different. There is, indeed, an imitativeness which belongs to the child just as it belongs to certain animals, but it differs from the imitativeness which appears in the acquisition of language. Facts become the more striking and interesting here, on account of the limited number of animals to be considered. We are practically restricted to monkeys, apes, parrots, and mocking-birds. Other animals, which might be included as "performing animals," and often are presented for exhibition as such, are to be excluded, not being spontaneous imitators, but constrained practisers of actions for which spontaneous aptitude is wanting. "Performing" dogs and pigs and birds and mice are not properly imitators. But monkeys, apes, parrots, and mocking-birds are distinctively imitators, and for the purposes of the present division of this inquiry, they are therefore to be regarded as a distinct class, since no other animals spontaneously imitate human action as these animals do. A subdivision of this "imitative class" is the next requisite, for it is interesting to remark that there is an essential difference in their imitative tendencies. The monkeys and apes have an anatomical organisation closely analogous to that of man, and they imitate, in their use of the general muscular system, mainly use of the limbs, not use of speech. The parrot and mocking-bird are far removed from resemblance of anatomical structure, and they imitate in vocal effort, not at all in general muscular movements. These contrasts involve a large deduction from the value of imitative acts on the part of the lower animals, as testimony in support of similarity of animal and human life. The apparent approximation in reality carries within it important evidence of wide severance. The references previously made (p. 170) to the imitative acts of the anthropoid ape show a strong tendency to imitate all the ordinary movements of man when walking from place to place, or sitting at table, but they present no evidence of a tendency to imitate the use of speech. The parrot, on the other hand, imitates man in respect of vocal exercise, and in no other respect. The less intelligent animal imitates that action which gives highest evidence of intelligence; the more intelligent animal (I do not say the most intelligent) imitates that action which is least of all the expression of intelligence. The dog, the most intelligent of animals, does not imitate. Another fact, however, needs to be observed, which does something to compensate, and so far restore the balance between the birds and the monkey tribe. If the parrot imitate the higher exercise, it does so quite clearly under sensory stimulus; it is not so clear that the imitative activity of the monkey race can be fully explained in this way. The listening parrot presents a case somewhat different from that of the observing monkey. Probably muscular organisation, and the tendency to act in accordance with the adaptations of the muscular system, may account for the circumstance that an animal having the anatomical structure of the monkey, capable of readily assuming a semi-erect posture, and of using the fore-feet to perform the functions of hands, has some muscular inducement (really a sensory stimulus) to imitate man, not manifested by the more intelligent animal, the dog, which has no muscular inducement to imitate human actions, but must experience muscular tendencies inclining in an opposite direction. If this consideration be sufficient, the imitative tendency of the monkey and the ape is explained on the ground of sensory stimuli, as well as that of the parrot. The evidence is more obscure in the case of the larger animals, but there seems no doubt that at least part of the explanation even in their case is found in nerve sensibility. The fact that the monkey is more actively imitative than the ape—the less developed brain more imitative than the more highly developed —must be classified along with the other facts which illustrate greater energy and agility in the smaller animal. And it must certainly stand as one of the facts adverse to the theory that brain development and intellect are necessarily associated.

With these contrasts before us, the superiority of the imitative actions of the child in acquiring command over the vocal organs is very marked. The child is intelligently observant of both movements and sounds, and by power of intelligent combinations does in the very earliest stages of vocal effort what none of the animals can attempt. Physical combinations are preceded by intelligent combinations, without which speech is impossible. The part which intelligence plays is conclusively shown by the illustrations afforded in the case of deaf-mutes, and children even more unfavourably placed. By deduction of important external aids, it becomes more obvious how intelligence struggles against its difficulties, and overcomes them. It is not too much to say that mind has triumphed over physical defect, and worked out an escape from a state of dumbness. It is no doubt true that deafness is generally the primary cause of dumbness—one physical defect hindering the development of the functions of an allied nerve tract, so leaving the vocal organs altogether unexercised and undeveloped. The mute is either completely deaf, or nearly so. In the majority of cases he is born deaf as well as dumb. There is, however, loss of speech by accession of deafness in the earlier years of life. Kussmaul says, "It seems that the time of puberty is the latest period of life at which deafness can deprive persons of the command of speech, which they have already acquired."[1] The vocal organs having been fully developed and persistently exercised, there is not subsequently a loss of power, even though the advantages of hearing be withdrawn. The labours of those who have undertaken the difficult but noble effort to gain for the dumb the power of speech, by mastery of their special disadvantages, have contributed most valuable evidence as to the relations of mind and brain. It is fully one hundred years since Samuel Heinicke, the Saxon schoolmaster (born 1729, died 1790), began his efforts to teach deaf-mutes to speak.[2] Since his time a large mass of evidence has been gathered, conclusively proving that deaf-mutes are capable of being educated, not merely to the use of written, but of spoken language. The essential relationship of intellectual and mechanical effort is strikingly illustrated by these educational experiments. The eyes are made to do work for the ears, which in ordinary cases do so much to simplify education. First, by drawings to represent familiar objects, the deaf-mute sees what object is referred to by his teacher. Next, by watching the mouth of the teacher while he slowly and carefully articulates the name of the object, the patient is induced to imitate the movement of the lips, and attempt so much of vocalising effort as is involved in adapting the organs of speech to giving forth the sound.[1] Thereafter the range of education is extended by the teacher resorting to such pantomimic action as may aid the understanding, while the pupil follows with imitative effort.[2] The dependence of the entire process upon intelligence, noticing objects, comparing representations of them, and observing modes of action adapted to the utterance of their names, is manifest. Such training first demands intelligence as its prerequisite, and next develops it in a higher degree, by affording to it a wider range of exercise. The attempt to vocalise, being more complicated than the attempt to produce written characters, contributes more powerfully to the training of mind. A boy in Leipzig, seven years of age, who was a deaf-mute, had within a period of six months learned to write, but he had no understanding of the meaning of the words, thus illustrating the lower form of imitative tendency. After that period he began to attempt vocalising, thus connecting pictorial representations and written characters with efforts at articulation,—a higher exercise of imitative power, in which greater demand was made upon intelligence, and greater development of it was the natural result. Thus have the deaf-mutes aided us in the important experiment of separating the distinct exercises involved, and showing more conspicuously how truly intelligence is the director of nerve energy. An intelligent power which is capable of discriminating and comparing pictorial representations with the objects they represent, distinguishing different forms of labial and lingual action employed by another person, and directing the organs of speech in the attempt to produce similar movement with vocalisation, places its possessor within the circle of the educable, even though there be organic obstacles to be overcome by him. In such cases, mind conquers the physical inaptitude, and at length makes the formerly inactive organ of speech a pliant servant of intelligence.

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[1] *Cyclop. of Prac. of Medicine,* (Translation,) vol. xiv. p. 866.

[2] Heinicke published "On Modes of Thought among the Dumb;" "Important Discoveries in Psychology and Human Language;" "*Samuel Heinicke, Sein Leben und Wirken.*" Stoetzner. Leipzig, 1870.

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[1] See note on "lip reading," Carpenter's *Mental Physiology*, p. 204.

[2] Imagine this experiment tried with a monkey, the most imitative in action, or with a dog, the most intelligent of animals!

In the present argument, it is important to distinguish between nerve sensibility, intellectual action, and motor activity. Education of the deaf-mute does not proceed without some use of nerve sensibility. If the ear does little, the eye does so much more. The picture, movements of the lips and tongue by the teacher, and accompanying gesticulations, are all essential. The sensibility of the optic nerve is largely employed. But such sensibility is insufficient to account for the facts. The retina, the optic nerve, and the optic centre in the brain all fulfil a distinct part in the process. Destroy the optic apparatus, and a second avenue to the intelligence is closed, as the auditory was in the first instance. But it is only an avenue, a nerve apparatus for conducting a class of sensory impressions. If such impressions are not transmitted, the intelligence is still the same, even though it is shut off from another inlet of information, and deprived of important occasions for its exercise. But while we speak of sensory impression in the brain, the deliberate comparison of one impression made by the pictorial drawing, with another made by the object itself, is an exercise for which the sensory apparatus is inadequate (see p. 305), and motor energy is insufficient, and for which a power higher than both is required. It is this higher power, and it alone, which provides for intelligent appreciation of the purpose of the instructor in directing attention simultaneously to the object and its pictorial representation. If the simple perception of the two things with dependent motor activity were the utmost possibilities in the case, the educational process could not advance. The look of recognition between pupil and teacher is the conscious agreement of two minds for the accomplishment of a contemplated end.

In accordance with the facts in this particular case (and with the general argument as to sensation, p. 305), there is a self-directed exercise of intelligence on the part of the deaf-mute, which is the most potent factor in the process. The most valuable efforts of the instructor, operating on the best developed brain, would have comparatively little influence, were it not for the voluntary and intelligent effort of the pupil. That this effort of the deaf-mute is in part imitative is clear, but the imitative process would be reduced to grotesque pantomime if evidence were wanting of the direction of the interpreting mind. In a very important sense, which holds true in all education, the deaf-mute is self-educated. His condition would have involved a very restricted exercise of intellectual power, if the skill and benevolence of the teacher had not brought to him important aid for mastering the restraint placed on the vocal organs; but that teaching would have been disappointingly slow and limited in result had there not been the self-directed and intelligent action of one eager to learn, and to escape the thraldom of enforced silence.

In confirmation of this view, there are recorded cases which enable us to form some estimate of the intelligence of the deaf-mute at the earliest stages of life. The following case, presented by Kussmaul, may suffice for illustration:—"It has been pointed out that from birth onwards, deaf-mutes have learned to recognise properly both things and relations. A case related by Kruse (*Ueber die Taubstummen*, Schleswig, 1853), bearing upon this point, is particularly instructive. 'A deaf and dumb boy was in 1805 found by the police, straying about Prague. Not being able to make anything out of him, they placed him in an institution for deaf-mutes, where he received instruction. When sufficiently educated to give accurate answers to questions put to him, he gave a description of as much of his former life as remained in his memory. His father, he said, owned a mill; he described the furniture of the house, and also its surroundings minutely; he gave a full account of his life while at home; told that his mother and sister had died, and that his father had married again; and that his step-mother ill-treated him until he had run away. But he neither knew his own name, nor that of the mill; he knew, however, that it lay to the east of Prague. Inquiries were made, and the statements of the boy were found to be correct. The police found his home, gave him his proper name, and secured to him the succession to his father's property.' From this we see that a deaf boy, who had not learned phonetic speech, had nevertheless stored up a multitude of accurate recollections, and was able, by the exercise of judgment, to arrive, through them, at correct conceptions of very intricate relations."[1] It is quite possible, as Kussmaul suggests, that the boy, after having been instructed, had recalled all the scenes of his youth, and brought the whole into intelligible unity before his mind. Such intellectual exercise on his part is not only probable, but even certain. Yet this does not in the least detract from the value of the evidence that he had, at the earlier stage, "by the exercise of judgment," arrived at "correct conceptions of very intricate relations." The possibility of afterwards reconstructing into a harmonious whole the scenes and relations of early life, presupposes that he had previously accurately distinguished and remembered the relations in which he was placed.

Still lower than this case it is possible for us to go in the records of loss of special sense with loss of speech, and prosecution of educational effort in face of great difficulties. The celebrated case of Laura Bridgman must be regarded as the crucial test of education with least possible aid of the senses.[2] Though it does not illustrate use of speech, I refer to it briefly as of value in the present connection. In her second year, Laura Bridgman, while suffering under scarlet fever, became blind and deaf, and was also in great measure deprived of smell and taste. Her exercise of intelligence in acquisition of knowledge of the outer world depended exclusively on the sense of touch. When Dr. Howe, her instructor, found her, she was seven years of age, having been born in 1829, and was a "lively girl," living in a village in the mountains. He made arrangements for taking her to Boston, received her into his own house, and began the arduous task of instruction. She, for her part, laboured most diligently, and, after having continued her studies for fully twenty years, was able to converse "readily and rapidly" by signs, to read books in raised character, to find any chapter and verse in Scripture, to keep a diary, and to write letters to her friends. The early stages of her education involved the following methods. Dr. Howe took such articles as a pen, a pin, a key, and spoon,—restricting names to monosyllables; the articles were laid on the table that she might feel them; she was then made to feel the doctor's finger as he formed the letters for pen according to the manual alphabet; and this was repeated until she grew familiar with the signs, and associated them with the things. Next, the printed characters were cut out and pasted on the articles, and thereafter single characters were cut, and she was set to arrange them in proper order, afterwards placing the name on the appropriate article, in order to test accuracy. She became conscious that she was making out the names "pen" and "pin." The smile of satisfaction passed over her face, and Dr. Howe could say, "I now felt that the first step had been taken successfully, and that this was the only really difficult one." The lessons were extended to embrace a larger number of objects; the numerals were learned, with marks of punctuation and interrogation. She became so deeply interested that "she worked eagerly and incessantly;" at times she was "too radiant with delight to be able to conceal her emotions." She carried on the exercise when alone, repeating over and over again the same word. While so engaged, she was seen to detect her blunders; turning her head a little to the side with a smile, she gave her right hand a slap with the left hand, as her teacher was in the habit of doing. As a stage in advance, types were made for her which could be fitted into openings in a board, leaving only the characters above the surface. With these she soon became familiar, and she began to arrange them rapidly. Thereafter she became equally well acquainted with the same forms raised on the surface of paper, and she was able to read printing as prepared for the blind.

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[1] *Cyclopædia of the Practice of Medicine*, Ziemssen, vol. xiv. p. 598.

[2] The case is reported in the Forty-Third Annual Report of the Perkins Institution and Massachusetts Asylum for the Blind. It is referred to by Kussmaul, is given at considerable length by Dr. Ireland in his work on *Idiocy and Imbecility*, p. 225; at still greater length in Kitto's *Lost Senses;* it is also described in George Combe's *Notes on the United States;* and in Dickens's *American Notes.*

At the earlier stages of this educational process, the child was only imitating, without recognising any intelligent end to be served; but from the moment she began to understand what was being done, she began the use of written language. Referring to the contrast between these two stages, Dr. Howe writes thus :—"The poor child had sat in mute amazement, and patiently imitated everything her teacher did. But now the truth began to flash upon her; her intellect began to work; she perceived that there was a way by which she could herself make up a sign of anything that was in her own mind; it was no longer a dog, or a parrot; it was an immortal spirit eagerly seizing upon a new link of union with other spirits. I could almost fix upon the moment when this truth dawned upon her mind, and spread its light to her countenance." It is upon this intensely interesting period in the history of the case that Mr. Dickens has dwelt with manifest joy, as one not to be forgotten by her instructor. Very fitly does Dr. Howe express the ground of confidence he had in persevering with a task so puzzling, and so full of suggestions of hopelessness. "Without the belief, and indeed the certainty, that the mind of Laura was endowed with some attributes which the most highly gifted brutes utterly lack, I should not have attempted to bring her out of her mental darkness into light, any more than I should have attempted to bring out the mind of my dog Bruno, which seemed to know as much as Laura then did, and which I loved and prized almost as much as if he had been human."

This case, along with the preceding illustrations of "lip language," strikingly illustrates the distinction between the merely imitative exercise and the discriminating power which is able to interpret and employ for its own ends arbitrary signs gathered together in a recognised order. As to acquisition of speech, it is obvious that analysis of the process gives us the following distinct facts :—(1.) observation by sight of lip movement; (2.) observation by hearing of vocal effects, the latter being the more important and helpful for the end contemplated, but both possible to animals; (3.) use of motor energy for vocalising, stimulated by a sensory influence, and possible to some animals; (4.) intelligent appreciation of vocal signs, and accompanying gesticulations, which may be seen in the dog; (5.) intelligent appreciation of the distinct characters, and their exact relations when combined to represent vocables, an exercise performed by no animal; (6.) an intelligent voluntary direction of motor energy towards the imitation of vocalisation for an intelligent end; (7.) voluntary exercise in vocalisation with the view of attaining facility in utterance; (8.) voluntary use of speech as an aid to discrimination of things, and to direction of the thoughts concerning things. The last introduces to the free use of speech as an intellectual exercise, and a powerful auxiliary for the development of intelligence. From these considerations it appears that use of speech implies acquisition by an imitative process possible to animals, and acquisition by means of intelligent discrimination not possible to animals. It further appears—and this is the essential point—that intelligent action is *not an after result* flowing from the lower imitative exercise, and developed out of it, *but a prerequisite,* without which the educational process could not proceed. The lack of this makes the education of the dog, or horse, or ape, by use of language impossible. The possession of it makes the education of the child possible, even when deprived of the aids of sight, hearing, and smell, the existing intellectual power being sufficient to overmaster the vast perplexities which such privation involves. Brain power is in such a case put at the greatest disadvantage for the use of motor energy in the management of the vocal organs. But these difficulties are overcome by a higher power operating in a manner superior to normal brain action. Motor energy is first directed by intelligence, and afterwards it is utilised to aid intellectual exercise, and also memory in storing treasures of knowledge. Thus mind is not superinduced on sensori-motor activity, as a later result, but is educed or led forth to aid the senses and utilise them, according to the true nature of *education.*

In confirmation of these conclusions, a few sentences from Kussmaul may be added, more especially as this author is disposed to assign a wide range of influence to brain action. Speaking of the German method of instructing deaf-mutes by "lip-language," or attempts at vocalisation, he makes the following statements:—"The instruction is of two kinds, *intellectual* and *mechanical.* 1. The *intellectual* aims at the production and combination of ideas drawn from sensory impressions. . . . 2. The *mechanical instruction* aims at the production of articulated sounds and words. . . . The intellectual and mechanical instructions are carried on up to a certain time independently of one another, but the intelligence and speech nevertheless react upon one another, and become intimately interwoven."[1] In fact, action and interaction are so essential here, that the mechanical cannot advance without the directing work of intellect; that is, action which is not originated by sensory or motor stimulus. The first step with Laura Bridgman, "the only really difficult one," as Dr. Howe has said, was the interpreting of certain signs; it was not sensory impulse, leading to co-ordination and co-action of nerve centres followed by combinations of motor activity. On these grounds the words of Professor Max Müller, though startling in form, and liable to be misinterpreted, are not too strong when taken in the sense intended—"without speech no reason; without reason no speech."[2] The two clauses obviously cannot have the same force, for of the two powers one must be superior to the other. It is impossible that speech should be the cause of reason, and at the same time reason be the cause of speech. Cause and effect cannot change places. But if it be meant that reason cannot be *developed* without use of language, and language cannot be *acquired* without use of reason, this is the truth which the preceding investigations seem to have established. If there were no discriminating power directing the use of special senses, speech could not be acquired, even though the mechanical appliances for vocalisation were in existence, and nerve force abundant. Intelligence is the essential requisite. But when the mechanical contrivances have been brought into use under the guidance of intelligence, and for rational ends, facility of speech is obtained. Then acquired language, with power of free vocal use of it, becomes an agency for higher action of intelligence, and higher development of all that belongs to an intelligent nature. This holds true in a still more important sense, when speech becomes the vehicle of communication between mind and mind. Man, by use of language, formulating his own thoughts, gives to them greater clearness and precision, and makes them at once helpful to others and contributory to personal advance.

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[1] *Cyclopædia*, vol. xiv. p. 872.

[2] *Science of Language*, vol. ii. p. 269.

Here the argument touches upon the disputed question in philosophy, Is language necessary to thought? There is no need for here entering upon the history of this dispute. The full answer to the question is, that a measure of thought is possible without language; but for free and accurate use of thought, it is needful to formulate our thoughts, and for this language is necessary. The legitimate conclusion obviously is, that language of some kind is needful for full use of intelligence. In this connection it is interesting to note that, in the case of Laura Bridgman, it was observed that when thinking alone she spoke on her fingers, and that the same exercise went on during her sleep when she was dreaming.

If now we pass from acquisition of speech, to the ordinary use of it in communicating thought to others, either conversationally or in public discourse, very strong confirmatory evidence is found for the distinctness and superiority of mental action. We see a discriminating nature using an instrument to aid it in its own proper work. Language first becomes an aid to the distinguishing of objects; next to the recollection of what has been recognised; by another step it becomes helpful in comparing the observations and thoughts of others with our own; next, it is an instrument for discovery of truth in a deeper and more abstract sense; and at length it becomes the vehicle of conveying to others the most matured results of reflection on the subjects which profoundly interest an intelligent being. In these familiar facts there is a clear and broad distinction between the mechanical and the intelligent. Admitting sensory stimulus and motor activity as quite essential for explanation of the use of our vocal organs, they are quite insufficient to account for the simplest and most ordinary use of speech. It is not at all difficult to find vocalisation which may be adequately accounted for by sensory stimuli. A sudden start, or unexpected infliction of pain, will immediately occasion exclamation (p. 324). The motor centres concerned with the management of the vocal organs have been proved to be co-ordinated with the sensory centres of sight and hearing. Any sudden and powerful action of either of these senses may therefore be sufficient to call forth expression. But to attempt to explain the ordinary use of language on the hypothesis that such brain action accounts for all, is simply impossible. The most ordinary conversation will supply ample material to demonstrate the unscientific nature of the attempted explanation. Observe a conversation in which facts are not merely stated, but diversity of understanding concerning the facts is expressed, making it an object for those interested to determine exactly how the matter stands, and it is obvious, after allowance has been made for sensory impression, and voluntary vocal action, that the most important fact, which is the key to the whole, is unexplained. Simple observation of the countenance of those taking part in the conversation makes us constantly sensible of this, and the current of conversation is largely decided by such observation. We see that our words are being heard and interpreted by others; but we also see that doubt has been awakened in the mind of some. This could not have been but for the hearing of the words spoken, but neither could it have been without *recollection* of other statements different in nature, and *comparison* of the two. The explanation lies beyond sensori-motor apparatus. This becomes clear as we listen to the counter-statements which follow. We almost *see* the doubt finding utterance for itself, and revealing its character as distinct from the sensory impressions and motor actions involved. The eye even more than the lips reveals that there is a discriminating and balancing process going on with the speaker while he utters his thoughts. All are familiar with the difference between the eye of a listener and the eye of the same man when expressing his own thoughts, and carefully guarding his words that they may quite accurately state his view of a case. We see the eye moving slowly hither and thither, looking all round the room, with a remote look which tells that the man is seeing nothing, or, we may say, seeing things without seeing them, because caring nothing for the images reflected on the retina. Such action of the eye is never seen in an animal. The speaker is deliberately stating his thoughts, arranging them in suitable order, carefully selecting his words, rectifying them at times by recalling a word and substituting another. Intelligence is revealing itself by the agency of speech. All the sensory and motor apparatus at command are needed to accomplish the result; but these are equally necessary for simple narrative, and for the most guarded expression of opinion. In this way deliberate utterance bears witness to a power higher than motor force.

Further evidence is presented by continuity of speech in public discourse when one is guiding the intelligence of many. Take the case of the public speaker who has pondered a subject, distinguished its subdivisions and their relations, resolving upon the general combinations he will adopt in order to convince others, but leaving for selection at the moment the words in which he shall express his thought. Having certain leading conceptions before his mind, he has grasped them in their nature and relations; but he has not formulated the discourse which is to be uttered when he is before his audience. He has apparatus, and stores of vocables, and a definite gathering of thoughts to be expressed. We listen at first to slow and guarded utterance; we see the eye kindle, and hear the words come faster and more emphatically; we see the evidence of rising and falling passion; we hear a deliberate course of argument, in which we see and hear the speaker carefully advance from one position to another; when this is over the aspect of things is changed, and we hear a strong appeal in favour of the conclusion commended to the audience. To say that all this is accomplished not with the aid merely of vocal apparatus, but by vocal apparatus alone, is simply to abandon the attempt to find a scientific explanation. The discriminating power at work cannot be overlooked, nor the careful adaptation to rational ends. Without long experience in speaking, and acquired facilities in utterance, and stores of vocables in the memory, the thing cannot be done; but that which we contemplate is a self-determined order of thought making itself felt beyond the circle of the personal life from which it comes, and bearing strong marks of the personality to which the utterance is due. There is a common impression made on the audience in so far as the sensory impressions are concerned, but there is a distinct result in the experience of each auditor, according as assent has been given, or doubt entertained, or dissent taken, while listening.

Striking confirmation of the difference between intellectual action and the sensori-motor activity involved in the use of vocal organs, is obtained by reference to facts connected with loss of speech, known as Aphasia. Dr. Bateman clearly draws this distinction:—"Speech is a complex faculty, consisting of two distinct elements, one physical, somatic, and material—a movement; the other psychical—the interior speech—the λόγος; and we must take care not to confound this inward with the outward speech or articulation, which is only a form of expression."[1] This is the distinction which has been made on clear evidence in the earlier part of this chapter, and which it is necessary to apply in order to explain the pathological facts connected with loss of speech. Accordingly, in explaining the use of the term Aphasia by such authors as Trousseau, Broca, Voisin, and others, he says it is used "to designate that condition in which the intelligence is unaffected, or, at all events, but slightly impaired; where thoughts are conceived by the patient, but he cannot express himself, either because he has lost the memory of words, or because he has lost the memory of the mechanical process necessary for the pronunciation of these words; or because the rupture of the means of communication between the grey matter of the brain and the organs whose co-operation is necessary to produce speech, does not allow the will to act upon them in a normal manner—the ideas are formed, but the means of communication with the external world do not exist."[2]

M. Broca of Paris has worked long and carefully at the condition of brain in cases coming under such a description as that just given, and he adopted the view that there is in general some disease on the rear portion of the frontal lobe, bordering the Sylvian fissure (see p. 18, innermost No. 1), and that the lesion is commonly on the *left hemisphere*, as previously maintained by Dr. Dax,—a fact which has been ascertained to be connected in some measure with the use of the right hand.

In other cases the lesion has been found on the right hemisphere rather than the left.[1] Professor Saunders, in addition to this, has found restraint on speech connected with lesion of the Island of Reil.[2] There is a large amount of evidence in support of the theory that the centre of speech is to the rear of the frontal lobe, but this cannot be regarded as a settled point.

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[1] *On Aphasia, or Loss of Speech, and the Localisation of the Faculty of Articulate Language*, by Frederic Bateman, M.D., p. 95; 2d ed., p. 159.

[2] *Ib.* p. 94. The second edition is enlarged and much enhanced in value.

Many of the recorded cases of loss of speech are full of interest to the psychologist. They illustrate considerable diversities in the degree in which speech is lost, presenting some analogy to the various difficulties in acquiring language, and enabling us the more fully to discriminate between intellectual activity and motor restraint. Those diversities include such facts as the following: complete loss of language under the influence of fever, followed by complete recovery of language after the fever had passed away; loss of speech in the same circumstances, with necessity for acquiring it anew as in childhood; permanent loss of speech on account of established disease of the brain, which is often a precursor of impending paralysis. Such a variety of cases greatly aids the work of discrimination between mental and physical activity. The observer, travelling along a pathway at the opposite extreme of human experience, at length discovers a condition as restricted as that of Laura Bridgman in her youth, when a barrier of physical difficulties blocked the avenues to her mind. Some illustration of the three classes of examples will suffice for the requirements of the present argument.

The *first* and simplest class of cases includes all those in which there is temporary loss of speech and language during a diseased condition, followed by full return of power along with restoration of health. One of the most striking examples of this occurred in the life of Mezzofanti (Giuseppe Gaspardo),[3] who was born at Bologna in 1774, was made Professor of Arabic in the University, 1797, went to Rome, 1832, where he was appointed Librarian to the Vatican, and was in 1838 made a

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[1] Impairment of Language, the result of Cerebral Disease, by Dr. W. A. F. Browne of Crichton Royal Institution, *West Riding Reports*, vol. ii. p. 278. Dr. Hughlings Jackson, *London Hospital Reports*, 1864.

[2] *Lancet*, June 1866; *Edinburgh Medical Journal*, August 1866.

[3] *Life of Cardinal Mezzofanti*, by C. W. Russell, D.D., Maynooth.

Cardinal, and died in 1849.[1] He was capable of speaking fluently in thirty languages, "and was acquainted in various degrees with seventy-two." When installed as a Cardinal he received congratulations from fifty-three members of the Propaganda. They offered "their greetings in their various tongues," and to each Mezzofanti replied in the tongue in which the congratulatory words had been spoken. "A brief attack of fever completely blotted out the seventy-two languages of which he was master, while the cessation of the paroxysm witnessed their restoration."[2] The effect was "to suspend his memory altogether."[3] A disordered physical condition affecting the brain deprived the sufferer of his vast stores of knowledge, as well as his facility of speech. So far, however, were these stores from being really lost, that removal of the physical disturbance was enough to show that they were still at command. The case does not illustrate a "blotting out" of impressions which needed to be imprinted anew on the substance of the brain, but a temporary obstruction to the use of that which was really in possession.

One of the most striking examples belonging to this class is that reported by Dr. S. Jackson, of Pennsylvania, as occurring in the experience of a clergyman, 48 years of age, caused by check of perspiration under exposure to the night air.[4] In this case the evidence is complete in proof of perfectly clear exercise of intelligence, with entire loss of speech. Dr. Jackson "found the patient in full possession of his senses, but incapable of uttering a word. The tongue was not paralysed, but could be moved in every direction; all questions were perfectly comprehended and answered by signs, and it could be plainly seen by the smile on the countenance, after many ineffectual attempts to express his ideas, that he was himself surprised, and somewhat amused, at his peculiar situation. The face was flushed, the pulse full and somewhat slow, and to the inquiries if he suffered pain in the head, he pointed to his forehead as its seat. When furnished with pen and paper, he attempted to convey his meaning, but he could not recall words, and only wrote an unintelligible phrase, 'didoes doe the doe.' Forty ounces of blood were drawn from the arm, and before the operation was completed speech was restored, though a difficulty continued as to the names of things, which could not be recalled. The loss of speech appearing to recur in fifteen minutes, ten ounces more blood were abstracted, and mustard poultices were then applied to the arms and thighs alternately. These means were speedily effectual, and no further return of the affection took place."[1] Dr. Jackson's analysis of the case is the following:—"Firstly, sudden suppression of the cutaneous transpiration, succeeded by cerebral irritation and determination of blood to the brain. Secondly, frontal pain immediately over the eye. Thirdly, perfect integrity of the sensations and voluntary movements. Fourthly, the general operations of the intellect undisturbed; ideas formed, combined, and compared; those of events, of time, recalled without difficulty. Fifthly, loss of language or of the faculty of conveying ideas by words, though not by signs—this defect not being confined to spoken language, but also extending to written language."

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[1] See *Philol. Soc. Proceedings*, January 1852. *Quarterly Review*, vol. ci. p. 23.

[2] *Impairment of Language.* By Dr. Browne. *West Riding Reports*, vol. ii. p. 291.

[3] *Life of Mezzofanti*, by Dr. Russell, p. 309.

[4] Reported in *American Journal of Medical Sciences*, February 1829, p. 272. Quoted by Dr. Bateman, *On Aphasia*, p. 56.

From this class of cases it appears not only that intelligence depends for its use of language upon a healthy condition of the motor centres through which it habitually regulates the organs of speech; but that intelligence may be undisturbed in its own operations, while a complete restraint is placed on the government of the vocal organs.

A *second* class of cases, including a considerable number of those reported, is that in which a more serious injury is inflicted, and language has to a considerable extent to be reacquired. Professor Graves of Dublin reported[2] the case of a Wicklow farmer, aged fifty, under paralysis of one side, who "was affected with an incapacity to employ nouns and proper names, he being able in other respects to express himself well." He however "perfectly recollected the initial letter of every substantive or proper name for which he had occasion in his conversation. . . . He consequently made for himself a little pocket dictionary of the words in most frequent use, . . . and during a conversation he would look in his dictionary till he found the word he wanted."[1] Another case is recorded by Dr. Hun of Albany, United States, the sufferer being a blacksmith, thirty-five years of age, who, after a long walk under a burning sun, was seized with symptoms of congestion of the brain, and for several days lay in a state of stupor. When he recovered from this state he understood what was said to him, but had great difficulty in expressing his desires in words, on account of which he resorted to signs to convey his meaning. If the name of a thing he wished was uttered in his hearing, he would say, "Yes, that is it," but he still continued unable to name it. "After fruitless attempts to repeat a word, Dr. Hun wrote it for him, and then he would begin to spell it letter by letter, and after a few trials was able to pronounce it. If the writing were now taken from him he could no longer pronounce it, but after long study of the written word and frequent repetition, he would learn it so as to retain it and afterwards use it. He kept a slate, on which the words he required most were written, and to this he referred when he wished to express himself. He gradually learned these words and extended his vocabulary, so that after a time he was able to dispense with his slate."[2] The striking feature in this case is the slow progress in reacquiring the words, in connection with which it is important to remark that there was no paralysis of the tongue. A complete contrast as to acquisition is found in a case reported by Dr. W. A. F. Browne, of the Crichton Institution, Dumfries, the sufferer being a person much more highly educated than either of the two just mentioned. "A young married lady, on recovering from dementia and stupor succeeding hysterical paralysis, was found to have retained no knowledge whatever of any of the events, or acquisitions, including languages, writing, music, etc., of her previous life, even of her marriage. She learned the alphabet and the language so long used by her, writing, knitting, etc., as a child, but with much greater rapidity and facility than a child could have done, and never regained the same command of the vernacular as she formerly displayed."[1]

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[1] Bateman *On Aphasia*, p. 57.

[2] *Dublin Quarterly Journal*, February 1851.

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[1] *Dublin Quarterly Journal*, p. 53.

[2] *Ib.* p. 58.

In such cases as these it seems certain that the action of disease produced some disturbance and change of brain structure. The change cannot involve a complete wasting or destruction of the centres concerned with speech, for some portion of the facility is retained, and there is undisturbed action of intelligence. The Wicklow farmer, while restrained in his use of names, was "able in other respects to express himself well." The Albany blacksmith "understood what was said to him." The young married lady had retained none of her knowledge, but she acquired "with much greater rapidity and facility than a child could have done," a fact which may partly be credited to a remnant of brain acquisition, but chiefly to her previous intellectual training, for the motor acquisitions were less available than the intellectual power brought to bear upon what was for her, in her recovery, completely new intellectual work.

The *third* class of cases includes those in which there is decided and incurable brain wasting, the loss of speech being only one of several symptoms, and commonly a symptom premonitory of more extensive and serious disorder. There is complete loss of will power over the motor centres which regulate the organs of speech, and yet there are conclusive and strong evidences of accurate intellectual action. Broca's case of Lelong, a labourer, aged eighty-four, in the hospital at Bicêtre, where he had been for eight years suffering under senile debility, is a very striking one. As the result of a fall down a staircase, he became unconscious, and was treated for apoplexy. In a few days he was convalescent; but he had lost speech, being able to articulate only five words, and these with difficulty. The words were "Lelo" for his own name, and "*oui, non, tois* (for *trois*), and *toujours*." "His intelligence had received no appreciable shock; he understood all that was said to him, and his brief vocabulary, accompanied by an expressive mimic, enabled him to be understood by those who lived habitually with him."[2] Having so few words at command, he used them often inappropriately. "*Oui*" and "*non*" sufficed for expression of assent and dissent; but every number was named three; and every thing besides was placed under "*toujours;*" whatever the object, its name was "always." Nevertheless, the patient clearly recognised the error involved in his utterance, and did his utmost to correct it. If asked how long he had been at Bicêtre, he said "*tois,*" but gave the correct number of years by holding up eight fingers. At ten o'clock he was asked what o'clock it was, and, as usual, he said "*tois,*" but he held up his ten fingers.

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[1] *West Riding Reports*, vol. ii. p. 289.

[2] Bateman's *Aphasia*, p. 9.

A very important case is recorded by Dr. Bateman, as having come under his own observation, that of a waterman named Sainty, fifty-one years of age, and who "seemed possessed of more intelligence than most men of his class." At the close of 1864, after unloading his vessel, he suddenly experienced loss of the power of speech, which continued for about three days, after which it began gradually to return. About two months later, February 1865, he felt numbness of one of the fingers of the right hand, and a month later fell down in a fit. He then came under Dr. Bateman's care in the Norfolk and Norwich Hospital, at which time there was "no want of sequence in his thoughts, but he was unable to give expression to them." He was discharged from hospital in June of the same year, resumed work, and continued at work till January 1866, when he fell down in a state of unconsciousness; a month later, the same thing occurred; and a repetition of the fit came upon him every few weeks, but still there was no paralysis. He was re-admitted to the hospital in January 1867, at which time he understood all that was said, could fetch anything when asked to do so, but could not name things, though he could recognise the name as correct when pronounced by another. Thus he was shown a poker, and asked what it was, to which he replied that he knew, but could not name the word. He was asked, Is it a walking-stick? No. A broom? No. A poker? To this he at once said Yes, with a smile of recognition. About three months after re-admission he had an epileptic fit, without paralysis; in less than a month thereafter another fit, followed by paralysis of the lower limbs, from which, however, there was recovery within a day. A week later the fit returned, with paralysis of the right side. In three days he had so far recovered the use of his limb as to be able to walk a few steps alone, but could not speak, though he made signs. He put his hand to his forehead as if in pain, and became so restless that he needed an attendant to keep him in bed. After this the case developed into insanity, under which he still recognised those known to him, and gesticulated violently, endeavouring "by the language of signs to supply the loss of articulate language."[1] In this case the evidence of intelligence continues through all the stages of slowly extending brain disorder, and it does not fail, even when the patient has passed into a state of excitement, becoming unmanageable, so that forcible restraint is necessary. He cannot govern himself, for he cannot command the restlessness of the sensitive system; but he is sensible of the greatness of the affliction which is upon him. Dr. Bateman does indeed say that "he became *imbecile* and quite unmanageable;" but the need for care in the interpretation of "imbecility" is manifest when we read immediately afterwards an account of Dr. Bateman's visit to the patient in the lunatic asylum:—"1868, July 9. I visited him to-day at the asylum, and found him seated on a bench. He evidently recognised me, but was quite unable to speak a single word, and he evinced the greatest distress at his inability to converse with me." Naturally he must at this stage be classed with the "imbecile," but it would be hard to tell how much more an intelligent being could do in order to show true appreciation of the position in which he was placed than this man did, recognising a friend who had done much for him, but speechless, agitated under the feeling of restraint, and liable to increasing agitation on account of his physical condition. I have seen highly intelligent and noble-minded men become confused in speech, and lose mastery over themselves in less trying circumstances.

It is affecting to consider what efforts are made by such sufferers to articulate a monosyllable. Often they are thrown into great excitement by the attempt. Dr. Hughlings Jackson and Sir Thomas Watson both record cases in which patients were unable to utter "No," as an effort in articulation, yet managed it when a very preposterous question was asked in order that there might be no possible doubt that a negative was required." I am indebted to Professor Grainger Stewart of Edinburgh University for a more pleasing illustration of this phase of difficult effort, attended by utterance obviously automatic. Dr. Stewart was demonstrating to his clinical class in the hospital ward a case of aphasia, and was insisting on the distinction between voluntary and automatic speech. After testing the aphasic patient in various ways, he asked him to say "No." The utmost effort was made by the patient, but in vain. At last he gave up the attempt, shook his head despondingly, and said "No," thus automatically uttering the word, which he could not accomplish by a voluntary effort.

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[1] Bateman's *Aphasia*, p. 65.

The three classes of cases thus presented illustrate by varying forms of evidence how largely the intelligence depends upon language for its exercise; and, at the same time, how intelligence finds exercise, even when use of language is denied. Without intelligence language cannot be acquired; the wide range of use assigned to it shows how large an influence it exercises in the work of intellectual progress; and through all stages of restraint upon the power of speech, it becomes clear that intelligence is at work within the narrow limits imposed, at work even with the result of throwing the whole body into agitation on account of the conscious barrier to utterance.

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[1] Hughlings Jackson, *On Affections of Speech*, p. 213.

CHAPTER XII.

ACTION AND REACTION OF BODY AND MIND.

THE evidence already presented in illustration of the correlative action of body and mind is sufficient to warrant consideration of the influence of each upon the other. In connection with sensation, motor activity, memory, and use of speech, we have seen that the origin of action may be either in the body or in the mind. Sensation results from involuntary contact with external objects, or is caused by determination of the mind in its search for knowledge. Reflex action is accomplished by mechanism alone, that is, by the action of the sensory apparatus on the motor; voluntary use of the limbs or of the organs of sense is originated and directed by intelligent purpose. There is a registration in brain tissue of acquired facilities, resulting from the use of sensory and motor nerves; and there is a preservation of knowledge depending essentially upon intelligent discrimination of minute differences and their relations. Use of speech involves a physical aptitude employed by the mind for expression of its knowledge of fact, its conceptions, or its inferences; but, even when vocal power has been lost, we find an action of mind interpreting the words of others, and giving tokens of its own exercise by such limited means of communication as remain at command.

Thus, in all these forms of exercise, the body and the mind are recognised as acting in distinct spheres, that is, each is found originating action, and securing its own results. The contrast is so complete, that both action and results are clearly distinguished. The satisfaction of organism, and the search for knowledge, are exercises so different, that they are in some degree antagonistic, bringing into activity two different sides of our nature. Organism accomplishes much without the aid of mind; intermediately, mind accomplishes, with the aid of the body, much for which organism itself is insufficient; and, in advance of this, mind, by a reflective process, reaches a knowledge unattainable by sensory apparatus and the largest stores of nerve energy. Mind and body constitute a unity in the life of a single person. They are not independent of each other, yet each can perform a different part, for which the other is incompetent. They are inter-dependent, if I may use the term, as the only one which adequately conveys the mutual dependence which subsists, along with the power of acting independently. But the inter-dependence varies in the course of personal history, the dependence of mind upon body being greatest at the early stages of life; the dependence of body upon mind being greatest at the advanced stages. The consistency of these two things is seen in this, that organism serves higher ends in mature life. Spontaneous action of body is most conspicuous in youth, but its activity is of a circumscribed range; the voluntary action of mind is most prominent in maturity, though the range of such activity varies greatly in the history of individuals, and that in a ratio proportionate to the degree in which the rational nature is cultivated, and asserts ascendency over the body and material existence beyond. In harmony with this ascendency of mind, the dependent action of body is of much wider and more important range than the bodily action characteristic of early life. A pure independence of mind is not known in our history; but ascendency of mind over matter is quite conspicuous in the life of man. There are, indeed, many cases in which an individual shows so much of the animal in his conduct that he seems little raised above the animals; but in all such cases we recognise that the man is either imbecile,—a sufferer because of undeveloped or wasted organism,—or he is living a life unworthy of the higher nature he has, and which is capable of controlling the lower nature, as no animal can control its life. It is certainly impossible to construct a science of human life, carrying a rational explanation of the achievements of the race, while we treat only of organic action, and do not recognise the ascendency of mind over matter.

The requirements are not met by a theory which represents the organic and rational features of our life as two phases belonging to a single order of being. Professor Bain has said that "one substance, with two sets of properties, two sides, the physical and the mental,—a *double-faced unity*,—would appear to comply with all the exigencies of the case."[1] A substance with two sets of properties, and these directly antagonistic, as represented by voluntary and involuntary actions, seems an unwarrantable hypothesis. Man represents more than sensori-motor apparatus, working an elaborate muscular system, by means of stores of nerve energy. That which is highest in him is not nerve force, and the further his "higher nature" is developed, the more obvious does this become.

In accordance with this representation, it will be found possible to trace, by clearly marked lines of interaction, the influence of body upon mind and mind upon body. We are familiar with the fact that *a disturbed bodily condition is an effectual hindrance to the action of intelligence.* Suffering from indigestion will depress a man so completely as to sadden his life, and make him feel unequal to the task of concentrated intellectual effort. A severe bilious attack will effectually stop one in any course of study, however deeply interested he may be in it. A violent blow on the head will deprive a person of consciousness, and lay him prostrate for days, leaving him dependent on friendly hands for the supply of food, which he receives without being aware of it. In such a case, life is sustained only by careful nursing, which carries it through a crisis, out of which the sufferer comes utterly weakened, not knowing what has happened, and testifying that these intervening days have been an entire blank in his experience. These are familiar facts, closely connected with the present inquiry. By many they are regarded as evidence that mental existence is not distinguishable from bodily. The argument may be summarised in a few sentences. Disorder of the digestive process, or disease of the liver, may greatly restrict mental action, showing that by disturbance of functional activity in other physical organs, the brain can be indirectly restrained, the action of intellectual power weakened, and, in more extreme cases, "personal experience" temporarily suspended. It seems to follow that intellectual exercises are the result of organic processes. Further, by direct injury of the brain itself, as the result of concussion, or fracture of the skull, and indentation of the bone or insertion of other hard substance, all exercise of thought may be brought to an end for a time, and the possibility of resuming intellectual activity depends upon restoration of the brain to a normal condition. Combining the evidence from indirect action of disease in other organs, with that from direct injury to the brain itself, it is argued that what we call "mental action" is a purely organic process. This argument is regarded by some as conclusive, apart from all other evidence, and on that account it deserves consideration.

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[1] *Mind and Body*, p. 196.

In order to estimate the argument at its true worth, we must distinguish exactly the several positions it includes, and afterwards ascertain how much it leaves unsolved. These positions are the following:—

1. Disturbance of other organs, such as the digestive, involves disturbance of brain. The brain, while performing distinct functions, depends for its own efficient action upon other organs performing healthily their functions.

2. Disturbance of an organ such as the brain, resulting from disordered action of another, clearly proves that the two are closely united in a common organic system. Thus the nutritive system is dependent on the nerve system, and that again on the nutritive.

3. Direct injury to the brain, from whatever cause, and in whatever form, occasions disturbance of its functional activity. Paralysis, sensory or motor, or both together, will supervene, according to the locality and extent of injury. Examples do, however, occur of injury, more commonly when restricted to one hemisphere, without any experience of personal disadvantage; but the rule is otherwise.

4 Disturbance of brain, whether by indirect or direct injury, generally involves disturbance of what is called "mental activity." There is no part of the sensory system, no part of the motor, no co-ordination of centres belonging to either, no acquisition of facility regulated by the cerebrum or brain proper, which is not related to mental activity. The sympa-

thetic system stands in a somewhat different relation, not being directly under control of the will. It is therefore not directly related to mental action, as the sensori-motor system is; but it is indirectly related, in accordance with the first position in this argument. On these grounds, I think it is clearly to be granted that, as a rule, brain disturbance carries with it disturbance of mental action.

5. From these data we cannot infer that mental activity is a purely organic process. It is shown that the cellular tissue of the brain depends for the evolution of nerve energy on regular and healthy blood supply, and that the whole mass of nerve fibres depend for functional activity upon evolution of nerve energy. It is further shown that, as all functional activity of the nerve system is dependent on evolution of nerve energy from pabulum supplied, the voluntary and intelligent use of the sensory and motor system illustrates the general rule. It is proved that the brain must be in an efficient state if it is to be the organ or instrument for accomplishing rational ends. But nothing more than this is shown. On the other hand, there are many facts to demonstrate that intelligence can prove its superiority to the defects of organism. The beginning of personal effort is an intelligent conception, with deliberate determination to accomplish a definite end. There is not evidence to uphold the theory that these acts can be accounted for by full development of the cerebral lobes. Minds deprived of the ordinary organic helps have demonstrated their power to triumph over their restraints, and achieve what is not ordinarily accomplished. Starting in an educational course with the consciousness of restraint equal to existing organic disadvantages, the sufferers have shown ability to master their difficulties, bringing intelligence and correlated nerve centres into vigorous exercise, with a minimum of aid from the sensory system. Illustration of this is afforded by the case of Laura Bridgman (p. 380), and a multitude of cases involving brain disease, of which examples will be given hereafter. There is no acute suffering, and no form of brain disease which does not more or less injuriously affect the action of mind, but even under such restraint, mental action can proceed according to recognised intellectual law. Functional activity

is restrained in the nerve centre, and mental activity is in consequence to some extent restrained also, but the mental restraint is not equivalent to the physical injury.

This will appear still more clearly if the negative positions involved in the argument are properly considered. Granting that an intimate relation does subsist between the brain and other physical organs, and that brain functions are retarded by a restraint placed on digestive functions, we must observe what positions are excluded under the argument.

1. The intimate relationship proved to subsist between the digestive organs and the brain does not involve any confusion of the functions belonging to the related organs.

2. Restraint upon functional activity of brain, through disorder of some related organ, is only temporary, and does not involve loss of functional power in the brain.

An exact analogy may be traced in the relations of brain and mind. Let us pass over to the standpoint of the theory that mind is a higher order of being connected with the brain, dependent for its own proper activity on healthy action of the brain, and operating through the brain as its only organ of communication with the sensory and motor system. Though disorder of the digestive organs involves disturbance of brain, it does not therefore follow that the stomach can perform the functions of the brain. And just so, though disorder of brain involves disturbance of mental action, it does not therefore follow that the brain can perform the functions of mind. If then it has been shown, by study of our experience, that the sensory and motor apparatus are insufficient to explain sensation and voluntary motion, and that we must acknowledge a higher order of existence if we are to account for intelligent discrimination and voluntary determination, no doubt is thrown on this conclusion by the fact that brain disorder occasions a check to mental activity. The unity of our nature implies that disturbance of any vital organ will involve disturbance for the whole being, and the closeness of relation between brain and mind in respect of functions—a relation much more intimate than between the stomach and the brain—makes it certain that disturbance of brain action must involve disturbance of mental action, which is constantly concerned with sensory and motor activity. The action of body upon mind, so far from being inconsistent with the theory that the mind is a higher order of existence fulfilling distinct functions, in reality confirms that theory, illustrating at once the intimate relations of the two, and their distinctness of nature and function.

Beyond this range of inquiry there are several fine and delicate distinctions connected with the facts of brain disease which must be reserved for a stage of investigation slightly in advance of the present.

Passing now to the other side of the question, it becomes needful to consider *what evidence human life affords of the action of Mind upon Body.* If within our nature there is duality of being, involving the union of two distinct forms of existence, there must be clear evidence of the action of mind upon our physical organism. That our nature is a unity, is granted; and it has been admitted in the preceding portion of this chapter, that everything which disturbs the sensory or motor system must exert some perceptible influence upon the mind also. But the distinctive characteristics of mind, and its functions as the governing power in human life, make it evident that there should be not only some degree of proof, but overwhelmingly strong evidence that mind has an ascendency over the body, even though it be an ascendency restricted by the laws of physical life. The laws of physical and mental activity so differ, that the physical nature cannot perform the functions of the mental, nor can the mental perform the functions of the physical nature. Clear as it is when we speak of our "personal life," that we make account of the body as part of ourselves, it is no less certain that we regard it as a subordinate part. It is recognised as a form of existence allied to physical nature generally, and dependent on physical existence around it for the means of its subsistence. But each individual regards his body as part of himself, and finds hourly evidence of the fact in the extent to which bodily functions are made to do service in accomplishing ends voluntarily selected by the rational nature. In accordance with this subordination of bodily existence, we see that mutilation and consequent deformity of body may occur on account of the many accidents to which the physical organism is exposed. Such mutilation we invariably regard as a serious injury, but still a subordinate injury not involving a true deformity of the life. We do, indeed, speak of "personal attractions," meaning to refer only to bodily appearance; and the expression is strictly accurate, inasmuch as we admit that the body is part of the person. Disfiguration of the body we recognise as a loss in "personal attractions," for all admire the beauty and symmetry of the body; but we do not for a moment allow that a real deformity of life is involved, as there is when a man gives himself up to a life of self-indulgence, sacrificing the best interests of himself and others for animal pleasures. There is a greater and a less—a higher and a lower—in human life, and the true deformity of nature and life is that only which touches the higher, making a man's conduct less a rational life, and more a merely animal life, than it is naturally fitted to be. In harmony with these considerations we acknowledge that a lofty and pure mind gives dignity and attraction to the body itself, as Plato has said in his argument as to the superiority of education over gymnastic, "not that the good body improves the soul, but that the good soul improves the body."[1]

The evidence that mental activity has a controlling power over the body is overwhelmingly abundant. There is no philosophy of human life possible, unless this vast range of facts be deliberately considered. The more fully this evidence is arranged according to its varying phases, the more conspicuous will appear the wide range of separation between man and animal, as well as the distinctiveness of mental activity, and the speciality of the laws under which such activity takes place.

The proof to which reference is here made includes facts which may be classified under the following heads,—rational control over our bodily movements; deep feeling injuring bodily health; mental occupation modifying experience of suffering; mind aiding recovery from disease; mental determination extending the range of endurance under toil or pain. Evidence under some of these heads has already been adduced, as on voluntary control of motor activity (p. 323, and onwards);

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[1] *Republic*, Book iii. 403.

and the power of personal determination to prevent shrinking of the muscles during a surgical operation (p 323). To these divisions it is not needful to return. It is, however, desirable to adduce here some additional illustrations, capable of being readily tested. The requirements of the present argument will be amply met by including this portion of confirmatory testimony under the two heads, power of emotion, and power of intellectual interest. The difficulty is not to supply evidence, but to select from the overwhelming mass examples sufficiently representative.[1]

1. *Power of emotion over the bodily condition.*—Emotions such as fear and joy exercise a powerful influence upon the body. In human life physical excitement is often a consequence of mental excitement produced by personal exercise of thought. The phenomena which illustrate this are peculiar to human life, not being found in the experience of animals. If we distinguish carefully the causes of our emotions, it is placed beyond doubt that in some cases emotion is roused by the action of external objects, in others by the exercise of the mind alone, while in a third class of cases there is a combination of both influences. Such classification, established on a multitude of well-authenticated cases, strongly supports the position that mind and body, while they together constitute unity of nature, are distinct forms of existence, acting and reacting upon each other.

FEAR is often occasioned by external objects of an unusual and threatening aspect. The lowest phases of such experience illustrate the analogy between animal and human life. The horse and his rider may be startled by the same object, and the experience in both cases is the result of nerve sensibility. But we make a transition which separates human from animal life when we observe that man is liable to experience fear because of *expectation* of danger, apart from local associations. A horse running regularly along the same road may have apprehension at a particular turn of the way where he has previously been alarmed. Within such limits as are indicated by local associations with past experience, animal life and human have much in common. But the distinctive action of intelligence, involving its possessor in an enlarged experience of fear, is seen when, by reflecting upon possible occurrences in the future, apprehension is awakened, which throws the body into agitation, though there is no external cause of alarm present to the view. Trouble of this kind does not disturb an animal's peace.

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[1] Reference may be made to *Illustrations of the Influence of the Mind upon the Body in Health and Disease*, by Daniel H. Tuke, M.D. ; *The Use of the Body in relation to the Mind*, by George Moore, M.D. ; *The Power of the Soul over the Body considered in relation to Health and Morals*, by George Moore, M.D.

The power of expectation is illustrated by experience of *vertigo or giddiness*, solely as the result of apprehension of danger. When speaking of the explanation of giddiness during rotatory motion afforded by the structure of the third or innermost chamber of the ear (p. 75), I took occasion to remark that it did not explain a similar uneasy experience without any rotation of the body. There are many unaccustomed to be on a height, who at once become giddy on the edge of a precipice, and even tremble as they walk on a road of sufficient breadth to provide for safety, when there is a chasm on one side. Simply on account of knowing the height reached, and being aware that part of the road to be travelled skirts the face of the rock, their body is thrown into agitation. When the point regarded with apprehension has been reached, and the mind contemplates the consequences of a fall headlong, giddiness sets in, the limbs tremble, and even the slowest progress becomes a source of distress. No animal climbs the mountain steeps with such apprehension, or stands on the trackless slope regarding it as a "giddy height." On the other hand, the person who is liable to the experience of giddiness escapes it according to the degree in which he is able to persuade himself that no great danger is incurred. No explicitness of testimony from others will secure this result, since the sufferer from giddiness is well aware that he is liable to uneasiness which others do not share. But if, by personal observation and reflection, he satisfy himself that there is in reality no serious risk, the giddiness is in some degree abated, and body and mind are gradually restored to a measure of calm. As the result of experiencing this uneasy feeling to a much greater extent than I could have wished, I am familiar with the facts here recorded, and have had reason to regret that there is such evidence of the power of thought and imagination to produce physical disturbance.

Closely related with such facts in the history of human fear is the *agitation often attendant on a sudden shock to the nerve system, leading to the imagination of suffering which has no reality.* An animal gives evidence of suffering only according to the pain endured. There is, indeed, diversity in the degree of sensibility among animals, naturally causing considerable diversity of result under similar forms of suffering. On an icy road, where there is risk of falling, one horse becomes much more nervously excited than another. Difference of nervous excitability in the two cases explains the contrast. But animals are not troubled with imagination, and do not cry out as if in anguish when they are unhurt. Such outcry is, however, common enough in human history under sudden shock. Professor Bennett, of Edinburgh University, has left on record a case reported to him by the chemist who had witnessed it. A butcher, working in the Market of Edinburgh, was in the act of hanging a heavy piece of meat on a sharp hook, when his foot slipped, and he was caught by the arm and hung suspended in the greatest anguish. He was taken down and carried across to a chemist's shop on the opposite side of North Bridge Street, where the case was at once attended to as one of urgency. The surgeon proceeded to cut open the sleeve of the man's coat, the sufferer crying out in great agony as this was done, yet, when the arm was exposed, it was found that the skin had not even been scratched. The hook had penetrated no farther than the coat.[1]

Dr. Noble has recorded a similar case in the experience of Monsieur Boutibonne, a literary man, who served in Napoleon's army, and was engaged "at the battle of Wagram, which resulted in a treaty of peace with Austria, in November 1809." Towards sunset, when reloading his musket, he was shot down by a cannon ball. He felt as if the greater part of both legs had been carried away, and all night he lay helpless, not daring to move, lest he should bleed to death. At early dawn, a medical officer came to his help. To the question, "What's the matter, my comrade?" M. Boutibonne replied, "Oh, touch me gently, I beseech you; a cannon ball has carried away my legs." The doctor examined his legs, and with a laugh bade him get up, as there was nothing wrong, when the sufferer leapt to his feet in amazement. The cannon ball had carried away the ground underneath his feet, and he had fallen into the trench which had been suddenly opened.[1]

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[1] *The Mesmeric Mania of* 1851, by Professor Bennett, p. 15.

These examples may suffice for illustration, without extending references to include examples of the power of grief, or the influence of sudden experience of great joy. Under each head distinct evidence can be presented demonstrating the power which purely mental action exercises over the bodily state.

2. *Power of intelligent interest to affect the bodily condition.*—Interest in objects and engagements, apart from varying conditions of health, contributes largely to healthy action of the body, escape from pain, and restoration from disease. Every medical practitioner recognises such facts, and every patient who has been for any considerable time under treatment knows how much his state of health is influenced by his mental occupation. If he is interested, occupied now with one subject of reflection, and again with another, turning with satisfaction from engagement to engagement, and rising into ranges of meditation, at once calm and elevating, the body itself is kept in a greater degree of rest, and the conditions are most favourable for recovery. A raging fever, or an acute form of suffering, may prevent the mind from maintaining concentrated interest in objects without, or subjects of meditation; but, if such concentration be possible, there is, by a purely mental action, a distinct contribution towards recovery from disease.

Many examples have been recorded of temporary escape from acute suffering under the influence of absorbing mental interest. I content myself with a single illustration. During the intense excitement in Ireland awakened by the case of Daniel O'Connell, Lord Anglesey, having gone over to Ireland, was so roused by it as to escape during a lengthened period from the suffering of tic douloureux, to which he was at other times a martyr. Mr. Greville narrates the circumstances in the following manner:—"It is an extraordinary thing, and the most wonderful I have ever heard of the power of moral causes over the human body, that Lord Anglesey, who has scarcely been out of pain at all for years during any considerable intervals, has been quite free from his complaint since he has been in Ireland. The excitement of these events, and the influence of that excitement on his nervous system, have produced this effect. There is a puzzler for philosophy, and such an amalgamation of moral and physical accidents as is well worth unravelling for those who are wise enough."[1] Under excitement, diminished sensibility to pain is common both in animal and human life; but only in human life does it appear as the result of continuous interest. It must, however, be admitted that our knowledge of the action of the intellect and emotions upon the nerve system, and upon the organs of secretion, is not yet so advanced as to enable us to present an adequate explanation of such results as those described in this case, and in many cases of a like kind. But the facts are familiar in human experience, and they illustrate the truth that the regulation of thought and attendant feeling is largely influential in promoting health, while neglect or surrender of such control may prove seriously detrimental.

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[1] Tuke's *Influence of the Mind upon the Body*, p. 131.

These two facts stand indubitable: Disturbance of bodily functions can retard intellectual action,—Thought, with its attendant emotion, can lower or quicken the vitality of the physical organism. As correlated facts they are strongly confirmatory of the position that there are in human nature two forms of existence acting and reacting upon each other.

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[1] *Journals of the Reigns of George* IV. *and William* IV., vol. ii. p. 109.

CHAPTER XIII.

WEARINESS, SLEEP, AND UNCONSCIOUSNESS.

In tracing the relations between mind and brain, the physical weariness attending on mental effort must be considered. The person engaged in manual labour, and the man sitting in his study thinking out a complex problem, both grow weary. The facts are undoubted, and importance must be attached to them. There are some who, on the single ground that excessive lassitude follows upon protracted study, argue that thought is thereby shown to be a function of brain. Others, seeing that such a conclusion is extreme and unwarranted, infer, on the same data, that there is no action of mind without attendant brain action. This less extreme position is still doubtful. It has been very generally assented to by physiologists, and may be true, but it has not yet been demonstrated; and it is desirable, in a matter so intricate as the relations of mind and brain, that we go no further than we are warranted by clearly ascertained facts, leaving ourselves open for additional light which may be thrown on the functions of the brain as the result of continued research.

The facts connected with the physical exhaustion attendant on severe study are sufficiently definite to afford a distinct department of evidence. While, however, we are here to proceed upon a recognised distinction between physical and mental labour, we must guard against an unwarrantable severance of muscle and brain in connection with human effort. It is customary to speak of "manual labour" and of "brain work," as if they were two entirely different things. But the supposed line of separation between these two does not exist. If we distinguish between "manual labour" and "mental work," there is a wide difference. But there is no "manual labour" which is not at every moment of its continuance real "brain work," as the preceding investigations have amply illustrated. The commonest work of the hands cannot be done without a draft upon the nerve energy supplied by the brain. All human labour is brain work, and all the work done by the lower animals in the service of man is also brain work. The best developed muscular system, with all the latent energy which belongs to it, is dependent upon its relation to the brain for the accomplishment of its work. We may, indeed, with strict accuracy say that the muscular system accomplishes what the brain itself cannot do, for there is a degree of muscular energy liberated by the nerve fibres greater than the nerve energy which sets it in motion (see pp. 79, 195). But the source of all manual labour, and all muscular effort of whatever sort, is not lower than the brain. It is therefore apt to be misleading, if we speak of manual labour as if it stood in direct contrast with brain work; or, on the other hand, if we speak of mental effort as if it were distinctively brain work.

Thus mental work and brain work are far from being contemporaneous and co-extensive. If there is no manual labour without brain work, it is clear that there is a very large amount of brain work which involves very little mental effort. In strict accuracy, it must be said that in the case of those whose occupations are restricted to the lowest forms of manual labour, by far the greatest proportion of brain work in their life is devoted to muscular effort. There may, therefore, be a lifetime of brain work with comparatively little exercise of thought. This may be illustrated by the limited vocabulary of the man who has never been taught to read. It has been reckoned that the whole words in regular use by such a man, and found by him sufficient to meet the requirements of his daily life, are not greatly over three hundred, while the moderately educated man has several thousands in regular use, and the vocabulary of highly educated persons is vastly wider (p. 361). While, however, there may be constant brain work, with comparatively limited exercise of intellectual power, it is clear that mental activity involves a large degree of brain exercise, and is quickly attended by a sense of physical weariness. In attempting to interpret the facts, it should be noticed that there is common ground to a considerable extent occupied by those who give chief prominence to the power of organism, and those who assign clear ascendency to mind. Whatever be the scientific explanation offered of intellectual action involving discrimination, inference, imagination, and rational government of our dispositions, it is admitted on all hands that a large amount of brain action is connected with the various phases of intellectual activity. The diversity of opinion on this matter is far from being anything so serious as a positive assertion of exclusive brain action on the one side, and a thoroughgoing denial of such action on the other. The range of discussion, and consequent difference of opinion, is greatly more restricted. It is freely granted on both sides that there is a large amount of nerve action connected with mental activity, and the difference of opinion is concerned wholly with the degree to which this has been demonstrated, and consequent physical weariness has been explained.

To avoid needless complications, it is desirable to enumerate the forms of brain action which must be considered as generally attending on the more ordinary mental exercises. They may be briefly stated thus: (1.) action of the special senses, and of the general tactile sense; (2.) action of the muscles concerned in the management of these senses, and specially of the organs of sight; (3.) co-ordination of sensory and motor apparatus required for use of the senses; (4.) action of sensory centres consequent upon use of the Imagination (p. 357), in part a renewal of sensory impressions, or a movement of the sensory cells consequent upon stimulus which imagination supplies; (5.) sensory and motor action consequent upon the stimulus coming from mental emotion, such as weeping, facial expression of sadness or sympathy. These are generally recognised phases of brain action closely connected with mental action. If only allowance be made for a possible diversity of opinion under the fourth head, it may be regarded as almost undisputed that all these attend on "mental activity." Thus the inquiry as to the explanation of physical weariness following upon the action of the mind, starts from definite physiological ground, with an ample store of facts. All these phases of brain action just enumerated, as they involve active use of brain energy, imply transformation of energy, consequent waste of brain substance, and inevitable sense of exhaustion. With these facts before us, we can reach some conclusions as to the weariness attending on mental activity.

First, There is large use of both sensory and motor apparatus in connection with all the ordinary forms of intellectual activity.—In observation of external objects, in guidance of the hands, in listening, in reading, whether silently or aloud, and in addressing others, there is continual nerve action, sufficient to account for the weariness experienced. The intellectual exercise may interest and even delight us; and we grow weary, not because the mind's interest has come to an end, but because physical discomfort is experienced on account of the need for physical rest and refreshing. In reasoning on this subject, due allowance has not been made for the extent to which nerve action is maintained while we are engaged almost exclusively in what are commonly called "mental exercises." Observe a person listening attentively, and you will soon become convinced that it is not merely the auditory nerves and the interpreting mind which are at work. You will notice the listener's eyes watching the lips of the speaker, and the expressions which flit across the face, glancing at times rapidly to others of the auditory, and coming quickly back again so as to miss nothing the speaker is saying or revealing by his countenance, sometimes turning to the ceiling or to the window when something has been said which appears doubtful, and again returning to mark what is being said. There is a large amount of nerve action in all this, leaving no ground for wonder that the brain at length grows weary. So in reading there is a constant strain upon the eyes. Or take the case of the public speaker, and you may observe from his eyes alone how large a portion of the sensory system is kept under strain. He not only thinks of what he is about to utter, and in what language to express himself, but he is turning his eyes first to one side of the room, and now to the other,—directing a passing glance to one face, again to a second, and again to a third. He feels any expression of approval or dissent, notices when his utterances awaken interest or call forth some sign of disapproval. Thus it is that a great part of the nerve system, both on its sensory and its motor side, is kept in very lively exercise, and when he sits down it is neither exclusively the vocal effort nor the intellectual exercise which accounts for the sense of weariness he experiences. In course of an address of quite moderate length there have been hundreds of currents of nerve energy streaming outwards and inwards, readily accounting for a large degree of weariness at the nerve centre. But such weariness is not to be attributed in any considerable measure to the intellectual action involved. Such intellectual effort, in the quietness of one's own room, and without any utterance of thought, would certainly have been followed by weariness, but not to that extent of physical exhaustion which a public speaker is apt to feel, and which, as a rule, is proportioned to the extent to which the speaker takes intelligent note of all that occurs while his words fall on the ears of others.

Second, All thought proceeds, to a large extent, by use of language, and thus seems to involve activity of the cells concerned with the acquisition and use of language and speech.—That language and speech are acquirements is admitted, and also that the acquisition in both cases implies constant use of sensory and motor cells. The artificial signs used to represent sounds, and the combinations of these into words, need to be acquired by sight, and also by vocalisation. In the case of the blind, we have seen that the acquirement of language depends on careful use of the sense of touch; in the case of deaf-mutes, on use of sight and visible signs; in the case of those who have lost both sight and hearing, upon peculiarly minute and complicated processes, by use of the tactile sense (p. 381). If the acquisition of language is an important aid to the development of intelligence, we know further that the extent to which written and spoken language is employed, becomes to some degree a measure of the intelligence of the individual. The higher the intellectual activity of the person, the wider the range of language employed by him, and consequently so much the larger the demand which his intelligence makes on the sensory and motor cells belonging to the centres by which language and vocalisation are utilised. There are many familiar facts which support this view, and give additional force to the argument establishing demand on brain activity as an accompaniment of intellectual effort. All thought, as it proceeds, involves some use of words or selected signs to give definiteness to it; the more carefully a man weighs his thoughts, the more he needs to formulate them in exact sentences, involving a still larger use of language; in order still further to add force to his thought, and give emphasis to the leading features of it, a man is often heard to utter, more or less audibly, the very words selected by him; and all such exercise, besides a large use of memory, draws upon the results of physical sensibility in the past, and this, as it is a recalling of sensory impression, may be regarded as somewhat akin to renewal of the action of the sensory cells concerned in the previous experience. All these exercises involve a demand on brain activity as an accompaniment of thought, in accordance with the theory that thought itself is the product of a power altogether superior to brain. And all these forms of brain action, taken along with the work which is constantly being done in sustaining the functions of vital organs depending on the nerve centre, are sufficient to account for the weariness which attends on ordinary exercise of thought. If there be in addition a demand for dexterity of manipulation, as in writing, engraving, drawing, painting, or mechanical contrivance, there is a proportionally greater demand on the nerve energy of the brain, and consequently the sense of weariness is experienced more quickly, or is more oppressive at the end of the same measure of time.

Third, Concentrated thought makes a severer demand upon all the forms of brain action connected with ordinary thought, and so quickens and increases the exhaustion of nerve energy.—The more concentrated the exercise of thought, the more completely does the mind depend on language. We cannot content ourselves with a few signs standing as representations of certain things or stages of thought. The several elements of our reflection require to be more exactly formulated, the nicer discriminations of meaning need to be marked, and for this we are dependent on words, the use of which seems constantly connected with brain action. This greater exactness becomes matter of mental effort, but it makes special demand upon the acquisitions of the nerve centre. There is, indeed, one respect in which it may be said that the demand on nerve action is diminished. In order to secure mental concentration, we draw off our attention from things external, restricting, as far as possible, the use of the senses, in order to escape the distractions apt to be experienced. We seek retirement and quiet, and even when these are found we may close our eyes, the better to avoid distraction from moving objects. All this seems voluntary restriction upon brain action; and at first sight it might appear as if, on the theory of a higher nature being concerned in purely intellectual effort, less demand should be made on nerve energy, and accordingly a slighter sense of weariness should be experienced; whereas it is well known that the exhaustion is great which attends on such thought. But a little consideration will show that such abstraction does not imply a mere release, or period of inactivity for the nerve centres concerned with the management of the special senses. On the contrary, the process of abstraction is directly connected with management of the body, and, as it is a management not by any means usual, it really involves a very special form of brain action, certain to be more than ordinarily exhausting. What is required for success in concentration is a species of deliberate inhibitory action, involving a considerable strain upon the nerve system. We do not simply leave the special senses to themselves. That is done when we have no self-selected occupation to engross the attention, and the mind is left to go "wool-gathering." This is the simplest and most easy of exercises, which should take a long while to weary a person. To leave the senses open to every kind of impression that can be made upon them, allowing the mind to be altogether under guidance of our sensibilities, is the easiest of occupations. But to concentrate the mind upon some abstruse subject, to be carefully thought out in all its aspects, is not only high mental work, but it implies hard physical work, in order that what is intellectual may be carried through with success. It implies a deliberate and well sustained guard put upon the senses, that they may not prove hindrances to us. Every one who has trained himself to such work knows well that it is physical work as well as mental. And even when one has attained a considerable measure of skill in such exercise, it is not found to hold true that the eyes can by-and-by be left to roam about, and the ears be set open to every sound that floats in the air. It is altogether otherwise. Rigid control over the senses cannot be relaxed even by the most successful student, and hence it is that there must be sense of great weariness as the result.

These considerations lead naturally to the conclusion that only a limited portion of time each day can be appropriated to such employment. And, as all nerve action involves weariness, with demand for nourishment and rest, we are naturally led to consider *the phenomena of sleep* as these are concerned with the relations of mind and brain. How sleep is induced, and what physiological changes result, are questions of much difficulty, on which a great deal has been written. We do not yet seem to be in possession of generally accepted conclusions on the subject, and I shall be content to deal with the phenomena of sleep as these come under ordinary observation.

Sleep implies rest primarily and specially to the sensory and motor systems, and through these to the general muscular system. It is thus essentially a physical state, providing for repose of the body. The whole body obviously shares in the advantage arising from a cessation of action and a uniformly calmed condition, excepting only those vital organs controlled by the sympathetic nerve system, which work without ceasing by night or by day. While the entire motor system, excepting the sympathetic, shares equally in the rest, there is some diversity as to the degree of inactivity secured for the sensory system. As sensibility or excitability of the sensory nerves is a uniform condition of a healthy state, it is maintained through sleep, and liable to be acted upon from without. The general tactile sense is that most liable to impression, as it is apt to be influenced by changes of posture, exposure of any part of the body, and changes of temperature. In this way, the reflex power of the motor system may be brought into use. Of the special senses, the sense of Sight, the most restless and active of all during waking hours, has the fullest advantage from slumber. The eyes give clearest indication of drowiness.[1] The other special senses, particularly smell and hearing, are more exposed to external influence. The peripheral organs of these two senses are so placed that the entrance conducting to the sensitive surface is continually open. Smell and Hearing are thus the sentinels on guard, ready to give warning of any disturbance or danger. Such are the essential modifications of the sleep state, affecting variously different portions of the nerve centre. Making allowance for these, and for the casual forms of sensori-motor activity occasioned by them, the whole nerve centre, with dependent nerve system, is allowed to rest in sleep. In such rest there is a double advantage to the brain, the demand upon nerve energy is reduced, and the supply of nourishment is all the while maintained, as the heart continues to pump up a steady course of fresh blood.

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[1] *Vide Causation of Sleep*, by James Cappie, M.D., Edinburgh.

In this connection we come upon *the phenomena of dreaming*, raising the question as to the extent of mental activity which may go on while a state of slumber is maintained.[1] This is a department of inquiry beset with special difficulty, but it is of obvious importance as bearing on the general problem. If mental phenomena be the product of brain action, or even if they be uniformly connected with activity of brain, rest of the nerve system in sleep should practically terminate mental activity for the time. But if mental phenomena imply the action of a higher nature distinct from the body, though existing in closest union with it, all that will follow as the result of slumber will be a cessation of those forms of mental action concerned with the use of the senses, and the management of bodily movements,—some limitation or modification of such mental exercises as are intimately connected with bodily life, with a possibility of independent mental action in harmony with the mental training of the individual. The present subject of inquiry is, Which view most harmonises with the recognised facts of human life?

At the outset, allowance must be made for the excited condition of the nerve system in the earlier stage of sleep. An excited nervous system is unfavourable to sleep, and even after falling asleep, the effects of excitement continue to be manifest. This is recognised in the case of children much excited in play, and the same rule applies in the case of concentrated study, implying close use of the eyes with all the disadvantages of artificial light. The excited nerve system takes some time to quiet, and the early period of sleep is in such circumstances less refreshing. In this period, which may be regarded as an intermediate stage between the waking state and that of profound sleep, the remaining excitement of the last hours of the waking state is apt to tell upon experience. This seems to favour a particular line of mental action. Dreaming is prone to take its direction according to the excitement in which the brain is left when the person sinks to sleep. In passing from the waking to the slumbering state there is a continuity of experience, by which the person is so far influenced that the effects may to some extent be apparent to an observer. In classifying the illustrative facts, some distinction is to be made between facts which belong more properly to organism, and others which cannot be explained without reference to mind. To the former class belong restlessness, starting, and a low murmuring sound sometimes heard. Analogous facts are seen in animal life. To another class must be referred articulate utterances, which indicate that the person is still intelligently occupied with the engagements which have been physically suspended. Such phenomena as these, while they must have a definite place assigned to them, so clearly belong to a border territory, that it may not unreasonably be argued that they are essentially connected with a lingering excitement of the nerve system, which gradually passes off as sleep deepens. For this reason I prefer to set them aside, and to rely exclusively on evidence of a different order, in which intelligence is legitimately held to be the originating source of recognised activity. The proof required for this purpose is that which indicates that intelligence communicates some influence to the slumbering body, rather than that the still excited body throws some disturbing influence upon the mind.

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[1] *Vide Stewart's Works*, Hamilton's ed., ii. p. 289.

Some have maintained that our dreams are all connected either with the period when we are sinking to rest, or with the period when we begin to wake; but any extended observation of others in profound sleep will contradict such a view. Restricting attention to persons in perfect health, and selecting hours when everything is quiet, it will commonly be found that the slumberer is perfectly quiet also; but at times the smile may be seen to come and go, a merry laugh may be heard, or a question addressed to a supposed auditor. It is often urged that such manifestation of thought or feeling implies a disturbed sleep. This cannot be maintained on evidence. There is a clearly marked contrast between mental action which involves a disturbing influence, and that which is compatible with undisturbed repose. If all who dream are disturbed, and if the disturbance lasts as long as dreaming continues, there would seem to be some at least who get little rest. But if a distinction be made between the different tokens of mental action during sleep, it will be found that such actions may be separated into two classes,—those which are disturbing and do indeed make sleep less refreshing, and those which interest and please the mind, so as to contribute a soothing influence to the slumbering body. It is one of the familiar observations of ordinary experience during our waking hours, that there are certain forms of mental action which agitate the body, while there are others of a kind pleasing in their influence, and stimulating to healthy action of the body. During the hours of sleep it is apparent that the same contrasts are experienced. Though the proofs of this are not so readily found as during waking hours, while the person is constantly observing external objects and conversing with others, as well as continually observed by others, they are conspicuous in the record of any extended course of observations as to experience during sleep, even excluding the phenomena which belong to the first and closing stages in the period of repose. Sometimes there is indubitable evidence that the slumberer is agitated by grief or fear; and again it is obvious that his attention is directed on some pleasing object, or he is reflecting on a theme which occasions gratification.

Before giving in outline some illustration of the evidence on which reliance is here placed, there is an argument against the opinion that dreaming is customary during sleep, to which reference should be made. It is founded on recollection as an available test of mental activity. The argument is, that if dreaming were so common as must be implied in the possibility of mental activity during profound slumber, there would be as ample recollection of our engagements during sleep as there is of the occupations of our waking hours. But there is an obvious and broad contrast between the waking hours and the hours of sleep in respect of facilities for recollection. If a man were to lie all day long on a couch, with his eyes bandaged, and no one were to enter the room, so that he were left altogether to his own thoughts, this would be the nearest approximation, in a waking state, to the condition of things during sleep. Such a person, spending his day in quietness and separation from external influence, as he is during the night, would find himself at the close of the day with a considerably shortened stock of recollections, in comparison with the store which an ordinary day's avocations afford. If, in order to apply to the period of sleep the test which memory affords, we deduct all the aids which come from use of the senses, and from the multitude of fresh associations supplied by the scenes of daily occupation, it will then appear that the argument from the scanty recollections of the morning has lost a considerable degree of its apparent power. But still further, there is no man, with all the advantages of active employment, who will consent to regard the recollections of the evening as an accurate test of the mental activity of the day. If this be so, still less can recollections be made a test of the degree of mental action maintained during sleep. In further estimating the value of the argument from recollection, it is to be observed that the best defined recollections we have of events occurring during our slumbers are those connected with definite scenes, that is, those which imply that we have during sleep attributed to the several senses activity appropriate to the imagined circumstances. If we find it more difficult to recall lines of thought which have been pursued, such perplexity is not at all peculiar to the thinking which we prosecute during our sleep, and may be accounted for simply by the want of definiteness belonging to the thought itself. Both in waking hours and in the hours of sleep it will be found, as a general rule, that more definiteness belongs to the action of intelligence when connected with the facts which our senses communicate, than with intellectual processes of a more reflective and abstract character. In accordance with this rule of mental life Memory has a less ready and retentive application when the mind is occupied with less defined subjects of contemplation. With these preliminary remarks indicating the conditions under which we can reasonably estimate the testimony of our recollections as to mental activity during sleep, we are prepared for a summary of the evidence itself.

1. *While the senses are sealed in slumber, the imagination is often occupied with a representation of scenes and occurrences such as are recognised by the senses.*—Under this statement are included the examples of the class of dreams most familiar to us. The sleeper, when liberated from the demands of daily work, and withdrawn from the relaxations of the social gathering, goes back at times upon the scenes of the past, sees again the familiar places where he has often spent happy hours, and enjoys communion as of old with those who were wont to be associated with him. In support of the conclusion that such use of the imagination is not to be accounted for by the effects which the circumstances of the preceding day have had upon the brain, such dreams involve restoration of past relations, in strict accordance with the state of matters at the distant period. Thus the agents depicted by the imagination are exactly as they were long years before. Those who are now in distant lands are present as they were then; those who are sadly weakened now are seen moving about in full vigour; those who have been removed by death are present taking their familiar part, and wearing their familiar looks. Testimony to such facts is so abundant, that there can hardly be a single individual who has not oftentimes had to report such experience. Some argue that the inconsistency of such imaginings with the facts of the present time shows that the mind is at least somewhat confused, and does not act with the same vigour as in its waking hours. But such an argument would be as powerful against the rational consistency of imaginative exercise during our waking hours, and it does not appear that any one considers himself confused in mind, or lacking in his wonted intellectual vigour, when he allows imagination to roam with delight over some part of the road he has travelled, or to linger in the midst of some of those social gatherings in distant days which seemed to have a special brightness over them. The inconsistency of the facts represented with the actual circumstances of the

sleeper at the time, shows how independent of present experience and position the exercise of the imagination is; the consistency of the dream in itself shows how rationally the sleeper employs his recollections. That dreams are always thus self-consistent, no one will say, for they are often enough grotesque in combinations, and not infrequently they involve the performance of impossible feats. Alongside this statement must, however, be placed the other, that even our "day dreams" are not invariably so rational as completely to escape a similar charge. We are not always consistent in our use of imagination, even when we are wide awake. If the fancies of our sleeping hours are more commonly grotesque and inconsistent, they are conceived under entirely different mental conditions. While the mind is for the time deprived of the aids of the special senses, it is liberated from their restraints, and no longer finds it needful to have regard to surrounding objects, or to the restrictions of time and space. Having a clear advantage as to facility of action, the agent is capable in fancy of compressing into a few minutes, occurrences which would take hours to accomplish under the ordinary conditions. But, while thus appearing to accomplish what is impossible, there is clear evidence of accurate intellectual exercise. This becomes so marked in many of our dreams that a lengthened conversation is carried through, all the parts of which are maintained by the sleeper himself. What remains in the memory after awaking is a consistent scene, as completely harmonious in all its parts as any actual interview of friends.

There is more difficulty in attempting to account for the incongruous combinations which occur at times in course of our dreams. Many of them may be explained by a restless physical condition, such as may be implied in the excited state of the brain before sinking to rest, the feverishness induced by cold, or endurance of pain. In illustration of the influence of suffering, Dr. Reid records the following experience:[1]—"I had got my head blistered for a fall. A plaster, which was put upon it after the blister, pained me excessively for a whole night. In the morning, I slept a little, and dreamed very distinctly that I had fallen into the hands of a party of Indians, and was scalped." Another class of dreams may be referred to disturbing causes around, such as unusual noises, strong odours, or considerable increase in the amount of light. The mind proceeds to make some account of its varying experience. It is not improbable that some additional incongruity may arise from the mixed character of our recollections, blending together occurrences which were considerably separated in course of the night. We can have no adequate test of the suggesting or stimulating occasion for many of the fancies which arise within the mind, but many of them must be attributed to our physical condition and our surroundings. After all allowance has been made, however, for the seemingly incongruous, there still waits for explanation a large amount of mental activity, giving evidence of a high degree of intellectual vigour.

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[1] *Reid's Works*, Hamilton's ed., p. 34.

2. *There is power of persistent determination and intelligent appreciation of previously formed purpose, influencing the sleeper from the beginning to the close of his slumbers.*—A determination to awake at a given hour can be exactly fulfilled.[1] There are some who feel that any such purpose has a disturbing effect upon their slumbers, specially if important consequences hang upon strict adherence to a determination to awake at an early hour. This is apt to prove true, if one has to transact urgent business, or keep an engagement of special importance. But the needless awaking at such hours as two o'clock in the morning, and again at four, of which complaints are made by those so situated, only illustrates how thoroughly the person continues to concern himself during sleep with the pressing interest of the time. Cerebral disturbance presents no adequate explanation. But a still better illustration is afforded, because more free from casual excitement, when one's determination concerns waking for the purpose of resuming ordinary engagements. Some deduction must here be made on account of the physical habit which becomes established by keeping to a regular hour of waking, as illustrated by the tendency to awake, when the intention of the sleeper had been to rest somewhat longer than usual. Even with this deduction, however, there remains a large amount of evidence confirmatory of the conclusion that the intelligent nature continues active while sound

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[1] *Reid's Works*, Hamilton's ed., p. 34.

sleep is maintained. I have repeatedly had tests of such action, by waking too early, taking note of the remaining time to be allowed to sleep, resolving to give no heed to the single stroke of the time-piece at the half hour, but to rise promptly when a succession of strokes was heard. This plan has been repeatedly carried out with such exactness in my own experience, as to afford clear proof of persistent determination during quiet sleep, a proof which is strengthened by the eagerness with which one starts up lest the inopportune waking had defeated the intention.

From observations as to the sleep of others I shall give only a single example. When on a visit in midsummer to a friend in a quiet rural district in the south of Scotland, I proposed to get up at four o'clock in the morning, to have a few hours' fishing before breakfast. One of the boys of the family hearing the proposal, made an earnest request that he might be allowed to go also. His parents gave permission, and a promise was made that he should be wakened at the proper time. When next morning at the time appointed I got to his bed-room, he was profoundly sleeping, and a door between his room and that of his parents was a little open. It thus became an object to wake him without disturbing them. I got down on my knees that I might call his name closely to his ear. This was done repeatedly without producing the slightest effect. Next I took his hand and worked his arm up and down, a process which resulted only in a slight murmur. More rigorous measures being required, I began to turn him from side to side. This when repeated induced him to say, "What's wrong?" The movement being still continued, he began to stir himself, and suddenly exclaimed, "Oh, I see what it all means!" and immediately a look of recognition settled the matter between us. It was not needful that I should utter a word of explanation, for his appreciation of the circumstances was instantaneous.

A most striking example of strong determination maintained through sleep is that recorded by Dr. Reid, Professor of Moral Philosophy in Glasgow. "About the age of fourteen," he tells us, he had always frightful dreams, as if he were falling over a precipice. He gives us the following interesting account of his effort to gain the mastery over these dreams:—"I thought it was worth trying whether it was possible to recollect that it was all a dream, and that I was in no real danger. I often went to sleep with my mind as thoroughly impressed as I could with this thought; that I never in my lifetime was in any real danger, and that every fright I had was a dream. After many fruitless endeavours to recollect this when the danger appeared, I effected it at last, and have often, when I was sliding over a precipice into the abyss, recollected that it was all a dream, and boldly jumped down. The effect of this commonly was that I immediately awoke; but I awoke calm and intrepid, which I thought a great acquisition. After this my dreams were never very uneasy, and in a short time I dreamed not at all."[1] Even if we suppose he invariably awoke, the laws of cerebral action are insufficient to account for the facts.

3. *There are many examples of concentrated intellectual action during sleep.*—Any mental exercise prosecuted during slumber will be in accordance with the intellectual habits and development of the individual. In the dreams of a child there are not likely to be examples of a kind which can come under this division of evidence; nor can we hope to find many illustrations of the kind in the case of those who give themselves little to close intellectual effort during their waking hours.[2] There must be intellectual interest and habitual exercise in reflective processes, in order to give any reasonable expectation that intellectual activity may be continued in a given direction during the hours of slumber. There must also be some distinction drawn between the experience of those noted for a high degree of sensibility, bodily and mental, such as Charles Lamb and De Quincey, whose mental activity largely involves sensory impressions and their effects upon the imagination, and the experience of those devoted to more abstract study, involving severance from external impressions. The two classes of thinkers are distinguished by very marked differences, and the testimony from them will naturally differ to a considerable extent. The dreams of such a man as De Quincey naturally assume a pictorial or dramatic form, and might come

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[1] *Reid's Works*, Hamilton's ed., p. 34; or *Dugald Stewart's Works*, vol. x. p. 321.

[2] *Dugald Stewart's Works*, vol. ii. p. 291. *Elements*, chap. v. sect. 5.

under the first division of evidence, were it not that the presence of finer sensibilities and phases of discrimination give predominance to the intellectual nature. In such a case as his we must make allowance for what he notices as true of Lamb, when he says: "The sensibility of his organisation was so exquisite that effects which travel by separate stages with most other men, in him fled along the nerves with the velocity of light." We must also have regard to "the pensiveness chequered by gleams of the fanciful, and the humour which is touched with cross lights of pathos."[1] We must make full account of what De Quincey describes as "the interaction between the author as a human agency, and his theme as an intellectual re-agency."[2] And we must add to these things the lonely pondering, characteristic of him, and often apt to be prolonged, as when Wordsworth writes thus of him:—"Mr. De Quincey has taken a fit of solitude; I have scarcely seen him since Mr. Wilson left us." We can well understand what there was to De Quincey in the departure of the stalwart Moral Philosopher of Edinburgh University, whose spontaneous, ever sparkling mirth and lofty sentiment spread sunshine around him on all sides. But this tendency to seek solitude gives an additional characteristic connected with his natural pensiveness. We must then expect somewhat different results in the case of a thinker such as De Quincey, physically predisposed for dreaming, with the natural tendency greatly intensified by use of opium, leading to his "Oriental Dreams," and such distinctively abstract thinkers as Locke, Thomas Reid, Dugald Stewart, and Sir William Hamilton. De Quincey had a dream-land always open during his waking hours, and in harmony with this we have large testimony as to his experience of mental activity during slumber.[3] If we take the abstract thinkers, we have testimony of a different kind. Locke in the midst of his polemic against Des Cartes, represents our dreams as "extravagant and incoherent for the most part," and quotes the case of a young man of good education, twenty-five years of age, who said that he had never dreamed in his life until he had a fever, from which he was at the time recovering. Dubious as to the frequency of dreaming, Locke says: "Wake a man out of a sound sleep, and ask him what he was at that moment thinking of."[1] This very test Sir William Hamilton applied in his own experience, and the results are recorded in the following words:—"I have always observed that when suddenly awakened during sleep (and to ascertain the fact I have caused myself to be roused at different seasons of the night), I have always been able to observe that I was in the middle of a dream. The recollection of this dream was not always equally vivid. On some occasions I was able to trace it back until the train was gradually lost at a remote distance; on others, I was hardly aware of more than one or two of the latter links of the chain, and sometimes was scarcely certain of more than the fact that I was not awakened from an unconscious state."[2] On the other hand, taking recollection as the test, without resorting to the plan of being wakened at different hours of the night, Dr. Thomas Reid could say, "For at least forty years I dreamed none, to the best of my remembrance."[3] But it must be noticed, in estimating the two statements, that Hamilton's is the result of deliberate experiment for purposes of observation, while, on the other hand, it needs to be admitted that both Locke and Reid had their reasonings somewhat coloured by polemic influences.

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[1] *Leaders in Literature*—Charles Lamb. De Quincey's Collected Works, vol. ix. p. 110.

[2] *Ib.* p. 112.

[3] See *Thomas De Quincey, his Life and Writings*, by H. A. Page.

I have gathered a number of examples of mental activity during sleep, which give evidence of concentrated intellectual effort. These include such varieties as the following:—a continuous course of reasoning, reproduced after waking; listening to a lengthened discourse, which must have been composed by the sleeper, and a long outline of which was afterwards given; reflecting on a problem, and experiencing such satisfaction with the result, that the person awoke, got up at once, and wrote notes of the positions. From the many valuable cases recorded by Dr. Abercrombie, I take an exceedingly striking example. "The following anecdote has been preserved in a family of rank in Scotland, the descendants of a distinguished lawyer of the last age. This eminent person had been consulted respecting a case of great importance and much difficulty, and he had been studying with intense anxiety and attention. After several days had been occupied in this manner, he was observed by his wife to rise from his bed in the night, and go to a writing-desk which stood in the bed-room. He then sat down and wrote a long paper, which he put carefully by in the desk, and returned to bed. The following morning he told his wife that he had had a most interesting dream; that he had dreamt of delivering a clear and luminous opinion respecting a case which had exceedingly perplexed him; and that he would give anything to recover the train of thought which had passed before him in his dream. She then directed him to the writing-desk, where he found the opinion clearly and fully written out, and which was afterwards found to be perfectly correct."[1] Such cases cannot be explained by "unconscious cerebration." Cerebral activity there is, of course, but it is shown besides that concentrated intellectual activity is compatible with profound sleep. My own mother, who continued through long years a sufferer, and was for the most part confined to bed, greatly lamented the loss sustained by absence from church on the Sabbath-days. She did the utmost that could be done to make up for that loss by very constant and careful study of the Bible, and by getting the members of her family to give the fullest outline they could of the expository discourse usually given at the forenoon service, and of the sermon delivered in the afternoon. The main current of her thought was determined by these two things, personal reflection on Scriptural statements, and such aids as were afforded in "the reported form of speech," by her own young people doing their best at reproduction, without violation of "copyright." By means of the latter aid her associations with the church services were constantly maintained. On one occasion she told us that she had dreamed of being at church, and had heard there an admirable sermon. She stated the text, became herself for this occasion the "reporter," and at great length gave us not only the main divisions of the discourse, but the principal lines of exposition and illustration adopted under each. To our surprise we listened to an extended account of a sermon none of us had either heard before, or reported to her, which she had not read, and which, after due consideration given, we were forced to conclude was an example of her own production, presented to a restricted audience, without violation of the ecclesiastical law against "female preachers."

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[1] *Essay on the Human Understanding*, ii. i. sec. 19.

[2] *Metaphysics*, vol. i. p. 322.

[3] *Works of Thomas Reid*, Hamilton's edition, p. 34. The letter from which this is an extract is one of great interest, and is given in Dugald Stewart's Life of Reid, included in Stewart's *Collected Works*, vol. x. p. 320.

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[1] Abercrombie's *Intellectual Powers*, 12th ed., p. 234.

A summary of the conclusions which may fairly be deduced from the large body of evidence at command, has been admirably presented by Dr. Noah Porter, President of Yale College, Connecticut, United States. He says: "The exercise of judgment in respect to the higher relations of thought varies very greatly in the energy of its action and the perfection of its results. There are many cases in dreams in which single steps, or parts of a series of steps in reasoning, are taken surely and correctly, while these processes are entirely disconnected with what went before and followed after, as if the rational powers had resumed for a single instant their full energy of function. In other cases the reasoning may be correct and the data may be false, and yet the falseness of the data may not be perceived. In still other cases, the data may be correctly discerned, and the conclusions correctly derived, so that both premises and reasoning combine to a valid and true conclusion. Even the more difficult feats of the invention and construction of the materials of an argument have been successfully performed in dreams. The creations of poetry, even to the selection of rhythmical words, the composition of sermons and addresses, have been often effected. Difficult problems in mathematics have been solved and remembered; new and ingenious theories have been devised, happy expedients of deliverance from practical difficulties have presented themselves, and brought relief from serious embarrassments." After giving examples in confirmation of these statements, Dr. Porter proceeds to say: "In all examples of this kind, the successful exercise of reasoning and invention is always in that form of activity to which the person is familiarly accustomed, and it is not always easy to distinguish between the suggestion to the memory of what had been previously achieved by a man when awake, and an original act of the mind upon the data brought before him for the first time in his dreams."[1]

If now a general survey be made of the evidence adduced as to experience in dreaming, two distinct conclusions seem warranted. *First,* that a considerable portion of the phenomena included under the general designation of dreaming may be accounted for by the excitement of the bodily state before going to sleep, or impressions made on the sensory system during sleep. *Second,* that a large body of the evidence accumulated by independent observers implies fixed determination and concentrated intellectual effort during sleep. With ground for a twofold classification of the facts adduced concerning dreaming, we are led to the inference that intellectual activity is compatible with that rest to the muscular system, the sensory and motor nerves, and the nerve centre, which is obtained in sleep. And towards an explanation of this intellectual activity we perceive that the evidence of such action is more abundant in the case of those who have developed their powers of reflection by voluntarily acquired habits of concentration. There is thus shown to be a continuity of intellectual work during sleep—a progression of thought from the waking hours into the silent hours of the night—which is more concentrated and valuable according to the mind's interest in the subject of study. Further, it is shown that the mind during sleep manifests all those characteristics known to belong to the individual in his ordinary avocations. The poet is in sleep poetical in his intellectual effort, the musician is musical, the mathematician is mathematical, the philosopher is philosophical. There is assuredly no warrant for maintaining that intellectual work can be uniformly prosecuted exactly as in waking hours; but if allowance be made for two things—the termination of such conscious relation to things external as is implied in the activity of the senses throughout the waking state, and intensity of intellectual interest in some employment not essentially dependent on the use of the senses,—it is proved that mental activity of a high order is compatible with physical repose in sleep.

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[1] *The Human Intellect*, by Dr. Noah Porter, President of Yale College, p. 336. Ample confirmation of Dr. Porter's summary will be found in Dr. Abercrombie's *Intellectual Powers, ut sup.* pp. 210-237.

From the phenomena attendant on the state of slumber, we may pass to deeper phases of unconsciousness at times connected with other states of body. We are accustomed to speak of our experience in falling asleep, as sinking into unconsciousness. But a restricted meaning is attached to the word "unconsciousness" in this case, and a much wider significance is assigned to it in other cases. If a person sitting quietly with book in hand of an evening in the family circle drop asleep for a few minutes, or if a member of Parliament be seen napping during a debate, or one of the audience fall asleep in church, we say he is unconscious of all that is going on around him. And yet this is so far from being strictly correct that any unusual movement in the room will cause the first to wake up, the division-bell will rouse the second to inquire what the vote is, and a sudden pause in the service will awake the third. There is thus unconsciousness of surrounding occurrences so long as they imply a continuance of the conditions under which sleep began; but there is a consciousness of any unexpected change, which is often sufficient to terminate sleep, by directing attention upon the occasion of disturbance. But that is in a deeper sense an unconscious state into which one passes who faints in stifling atmosphere, or under sudden fright, or is subject to epileptic fits, or who is caught in some catastrophe, receiving a violent stroke on the head, or being sorely crushed in machinery, or is placed under dominion of chloroform preparatory to a surgical operation. Any one of these cases illustrates a completely unconscious state, which requires consideration in connection with the relations of mind and brain. The person who lies in this condition gives no evidence of mental activity, though the action of the vital organs is continued. Communication between the patient and the friends around him is completely broken. No word tells upon the ear,—no sight is possible to the eye,—puncturing of the skin occasions no pain,—tickling of the soles of the feet produces no reaction. In such cases, there are different degrees of alteration in the nerve system, involving a shorter or longer continuance in the condition of unconsciousness. At one time unconsciousness may not last for more than a few minutes, at another it may be for the greater part of an hour, and at another it may continue for days. An explanation of this condition in all the aspects in which it affects human life may always continue an impossibility. When the aids of consciousness and memory are lost, the sufferer is deprived of the means of contributing personal testimony, and the observation of others extends only a little way. We are, therefore, practically restricted to a study of *the conditions which lead to* the loss of consciousness. When we turn to these, it appears that this physical condition may be induced by mental as well as physical causes. Beyond doubt the essential feature in the condition is suppression of the ordinary functions of brain. And that may be induced either by direct injury to the organism itself, or by undue disturbance of it through agitation of mind, involving interference with the functional activity of the brain. The disturbance may come either from within, or from without; but temporary injury to the brain is the consequence, and the twofold source of disturbance affords additional illustration of the correlation of body and mind.

1. *The state of unconsciousness may be induced by physical injury involving interruption of brain activity.*—While unconsciousness may be traced to physical causes, it is not every kind of physical injury which is attended by results so serious. A very large amount of pain and even bodily laceration can be experienced without any threatening of loss of consciousness. This may be illustrated by reference to *fainting.* It often happens that a much more serious amount of suffering is endured by the man who shows no tendency to faint, than by the person who has sunk into the condition more alarming to onlookers. In accordance with this contrast, the person of "nervous temperament," that is, the person low in muscular energy, and sensitive to every influence which acts upon nerve excitability, is prone to faint under experience of discomfort which would not much disturb a person in a high degree of physical strength. But, while here looking at purely physical conditions, we cannot altogether exclude reference to the mind. The person who is in a nervously excitable state greatly aggravates the effect of outward influences by the action of the mind

in attending to them. In so far as the influences inducing faintness are purely physical, the tendency will be quickened by increased measure of deleterious influence, such as exhaustion of the atmosphere in a crowded apartment. In so far as the influences operating are mental, the result depends upon the extent to which the person directs attention to the cause of uneasiness, or keeps the attention turned on other considerations, so averting the mind from physical impressions. The result is not calculable as in the former case, but will be according to personal determination, that is, the action of the individual mind. It is when the body is weakest and the nerve system most excitable that the action of the mind is most prone to aggravate the risks of fainting. Here it should be observed that the accession of mental influence is more especially characteristic of liability to the more transitory form of unconsciousness. As this is apparent, it points to the consideration, that low vitality involving nerve excitability in absence of normal power of control, is in itself an approximation to the unconscious state.

When we pass to a more aggravated form of unconsciousness, such as is seen in an epileptic fit, there is more thoroughly established brain disorder, and less influence of mind determining the physical condition under the paroxysm. The patient may, indeed, increase his personal uneasiness by apprehension of the approaching attack, and may even accelerate its advance; but the state of paroxysm, which interferes with normal sensory and motor action, is purely the result of brain disorder, and not at all the effect of mental action. If next we advance to the unconsciousness which is not consequent on a diseased condition of brain, but upon violence inflicted by a blow or a fall, there is nothing of mental influence contributing to the result, though an effectual interruption is occasioned to mental activity, as well as to the ordinary action of the sensori-motor system. The man is for the time incapable of physical activity, and equally incapable of mental.

2. *A state of transitory unconsciousness may be induced by mental action when the physical condition is healthy.*—Sudden tidings, either of a peculiarly joyous or of a particularly sorrowful kind, often give the physical nature an unexpected shock.

Such a shock is often sufficient to throw the recipient of the tidings into a faint. The prostration so witnessed is not the result of a previously disordered condition, nor is it the direct effect of the sensory impression when the words are spoken; it is the consequence of the interpretation put upon the words, and the anticipation of results seen to be involved in the tidings communicated. The effect is the same as if a blow had been received on the head, and so we speak of any calamity as "a sad blow" to the person concerned. There has been no use made of physical force, there has been nothing more than the utterance of a single sentence, but the hearer of it feels as if a blow had been delivered, and as if a sudden quiver had passed over the whole body.

This same result is apt to occur when, instead of a sudden message being received, there has been long continuance of excitement and anxiety. This is well illustrated by an incident related by Dr. Santagata, which occurred early in the career of Mezzofanti, when he stood a public examination in philosophy. As a student at the University of Bologna, and a candidate for the degree in philosophy, Mezzofanti was, according to custom, called upon publicly to defend a series of philosophic propositions against the objections stated by the examiners. "For a time the boy's success was most marked. Each new objection, among the many subtle ones which were proposed, only afforded him a fresh opportunity of exhibiting the acuteness of his intellect, and the ease, fluency, and elegance of his Latinity; and the admiring murmurs of assent, and other unequivocal tokens of applause which it elicited from the audience, of which I myself was one, seemed to promise a triumphant conclusion of the exercise. But all at once the young candidate was observed to grow pale, to become suddenly silent, and at length to fall back upon his seat, and almost faint away. The auditors were deeply grieved at this untoward interruption of a performance hitherto so successful; but they were soon relieved to see him, as if by one powerful effort, shake off his emotion, recover his self-possession, and resume his answering with even greater acuteness and solidity than before. He was greeted with the loud and repeated plaudits of the crowded assembly."[1] Any one who has gone through an ordeal of this kind, and has experienced the nervous excitement which it entails, knows that there is both a physical and a mental element to be taken into account. There is a gradual abatement of physical strength experienced when the effort has been protracted. But quite distinct from this, and not resulting from ordinary functional activity of the cerebrum, there is apprehension as to the result of the discussion, doubt as to whether the questioning is being fully understood, and a fear lest it should prove impossible to keep up the standard attained, and to fulfil the expectations of friends. All these apprehensions cause a physical agitation, which, if it be allowed to grow, will soon involve the entire mental exercise in confusion, and may at length throw the body into a state of unconsciousness. Such an example as this serves a double purpose illustrating how a purely mental anxiety may awaken physical agitation, and how naturally it follows that such physical excitement tends to destroy control of the nerve system, and at the same time to distract and obstruct intellectual action. In view of such occurrences, there can be no warrantable perplexity in the fact that the physical prostration of the unconscious state not only puts a check on consciousness of sensory impression and of motor activity, but also on higher intellectual exercises, all of which must be impossible under the conditions. The facts connected with an unconscious state are so far from being adverse to the theory of the distinct nature of mind, that, if on one side they illustrate the power of the body in restraining mental action, they also illustrate, on the other, the power of mental activity to throw over on the body a degree of agitation which it is not able to bear.

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[1] Russell's *Life of Mezzofanti*, p. 139.

Before passing from this division of the subject, there are certain phenomena of an abnormal type, including somnambulism or sleep-walking, the state of trance, and the mesmeric sleep, to which a brief reference seems desirable. There is a sufficient body of evidence as to such abnormal phenomena to call for an explicit reference, and to afford some test of our arguments as to the relations of mind and brain.

In somnambulism or sleep-walking, the mind is occupied as in dreaming, but the dreamer gets out of bed and puts into execution the purposes formed in his dream, exactly as he would do were he awake and in his ordinary attire. As a rule, the eyes of the somnambulist are wide open, but at times the person appears with closed eyes, yet apparently distinguishing objects around. Dr. Dyce of Aberdeen reports a case, the account of which is repeated by Dr. Abercrombie, of a servant-girl who was subject to fits of somnolency during the day, under which she "became capable of following her usual employment." "She repeatedly dressed herself and the children of the family, her eyes remaining shut the whole time."[1] This case differs in some respects from ordinary somnambulism. In all cases which have come under my own observation, the eyes have been wide open, but never directed upon any of the objects in the room, and never upon myself, even when a conversation was maintained with the sleeper. The pupils have been always more dilated than in the natural state, lacking such expression as appears when observation is concentrated on an object, and have uniformly had a remote look, as if the person were seeing beyond the walls of the room. There can be no doubt that in this condition the person experiences a considerable degree of cerebral excitement, unfavourable to natural repose. Children of nervous temperament are often liable to sleep-walking, if allowed to engage in very exciting games just before the ordinary hour for retiring to rest. If they are to have the full benefit of their sleep, and to be saved the consequences of establishing a habit of cerebral excitement during their slumbers, exciting games must be ended at least two hours before the usual time for retiring, a rule which would be well applied to all concentrated brain effort, if the first hours of sleep are to be thoroughly refreshing. Light reading before going to bed is as good a prescription as a light supper. There are mental conditions favourable to sleep as well as physical. In somnambulism there is, as I have said, actual performance of what is contemplated during the dreaming state. Is not this, then, the difference between dreaming and somnambulism, that the dreamer appears in some measure to recognise that he is sleeping, whereas the somnambulist does not? Accordingly it is a bad expedient to awake the somnambulist when he is moving about. Such waking gives a shock to the whole body; it is a sudden startling of the person by the discovery that he is engaged in an unnatural and dangerous exercise, and this discovery involves a degree of agitation which is altogether escaped if he is not wakened. Nor is there any need for wakening in order to direct his movements, for in the somnambulistic state he is capable of maintaining two perfectly distinct courses of thought, and gradually mingling them, as we do mix up utterly inconsistent facts in our dreams. Thus a child in the somnambulistic state will play over again the game he was engaged with before retiring to rest,—will rush about the room as if pursued by his companion,—will avoid the table and chairs as he runs, doing everything exactly as if awake. If, while he is in full career, one of his parents address him by name in the ordinary tone, telling him that he should go to bed now, he will do it at once, and commonly will do so without going through the feint of putting off his clothes. The two mental exercises are quite readily intertwined, and it becomes obvious that the mind has taken some account of the fact of sleep. So any one bent on an excursion, and found unlocking the street door, may be easily stopped, either by the person addressing him falling in with his intentions, and telling him to take a particular direction, or distinctly advising him to go to bed meanwhile. I have repeatedly advised the somnambulist to go back to bed, and, after a little appearance of perplexity, he did so, as if recognising that he was asleep, though occupied otherwise. It is clearly shown by a large number of the recorded cases, that in this state the mind is capable of following two distinct trains of thought, and so combining them as to work them into harmony for the regulation of the conduct. In this way the somnambulist appears to himself to gain two ends at once, or his purpose seems to him to be accomplished, while in reality the purpose of some adviser who has become aware of his state is fulfilled. A further fact deserves notice, as throwing light on the memory test applied to settle the problem as to the extent to which dreaming is characteristic of our sleeping state. The somnambulist comes out of his sleep with no recollection of what he has done in walking hither and thither, and often without any remembrance of the mental exercise through which he has passed. A very good example of the somnambulist's conduct is given by Dr. Abercrombie. He says:—"I have received from an eminent medical gentleman in London a case presenting some interesting features, which occurred in the person of a young man residing in his house as a pupil. This young gentleman was a zealous botanist, and had lately received the highest botanical prize from a public institution. One night, about an hour after he had gone to bed, after his return from a long botanical excursion, his master, who was sitting in a room below, heard a person coming down stairs with a heavy measured step, and, on going into the passage, found his pupil, with nothing on him but his hat and his shirt, his tin case swung across his shoulders, and a large stick in his hand. 'His eyes,' says my informer, 'were more open than natural, but I observed he never directed them to me, or to the candle which I held. While I was contemplating the best method of getting him to bed again, he commenced the following dialogue: "Are you going to Greenwich, sir?" "Yes, sir." "Going by water, sir?" "Yes, sir." "May I go with you, sir?" "Yes, sir; but I am going directly, therefore please to follow me." Upon this I walked up to his room, and he followed me without the least error in stepping up the stairs. At the side of his bed I begged he would get into the boat, as I must be off immediately. I then removed the tin case from his shoulders, his hat dropped off, and he got into bed, observing he knew my face very well,—he had often seen me at the river's side.' A long conversation then ensued between him and the supposed boatman, in which he understood all that was said to him, and answered quite correctly respecting botanical excursions to Greenwich made by the professor of botany and his pupils; and named a rare plant he had lately found, of which the superintendent of the botanic garden had seen only one specimen in his life, and the professor only two. After some further conversation he was asked whether he knew who had gained the highest botanical prize; when he named a gentleman, but did not name himself. 'Indeed!' was the reply, 'did he gain the highest prize?' To this he made no answer. He was then asked, 'Do you know Mr.——?' naming himself; after much hesitation, he replied, 'If I must confess it, my name is ——.' This conversation lasted three quarters of an hour, during which time he never made an irrelevant answer, and never hesitated, except about the prize and his own name. He then lay down in bed, saying he felt tired, and would lie upon the grass till the professor came. But he soon sat up again, and held a long conversation with another gentleman who then came into the room, when he again understood everything that was said to him, and answered readily and correctly, sometimes uttering long sentences without the least hesitation. After a conversation of about an hour, he said, 'It is very cold on this grass, but I am so tired I must lie down.' He soon after lay down, and remained quiet the rest of the night. Next morning he had not the least recollection of what had passed, and was not even aware of having dreamt of anything."[1]

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[1] Abercrombie's *Intellectual Powers*, 12th ed., p. 244.

In this case it is to be observed that the somnambulist walked up-stairs while supposing himself already on the water's edge, and only when he got to the floor above did he fancy that he had reached the boat. He recognised no inconsistency in the supposed boatman talking freely on botanical matters, or inquiring about the prizes which had been gained, though he was embarrassed by a reference to his own name, obviously because of reluctance to boast of his honour, not because of any surprise that the boatman should be able to name him. Along with these features of mental exercise, there was a sense of weariness which inclined him to lie down in bed, and this it is doubtless which operates in ordinary experience to keep us in bed, notwithstanding that we are quite actively engaged in our dreams.

The state of *trance*, whether it may be classified under aggravated hysteria, or regarded in a still more serious light, as it involves some degree of brain disorder, might be reserved for the following chapter. But it is well to introduce such brief reference as will suffice, while the subject of unconsciousness is under consideration. This state, in the variety of illustrations of it which are recorded, is a direct result of a disordered nervous condition. Commonly there is a low state of physical strength, and with that often an excessive and abnormal excitement of the nerve system. There are many recorded examples of liability to this condition during a period of weakness or suffering. I take two illustrations from "Cases of Obscure Nerve Disorder," given by Mr. J. Handfield Jones, M.B., of St. Mary's Hospital, London. The first is the case of a railway porter, aged thirty-four, who was brought to the hospital "perfectly insensible," and limbs "quite relaxed." He had met with no accident, and had not suffered from any epileptic attack. He was brought in "on February 3, 1874, about 2 A.M.," and continued in the unconscious state, notwithstanding cupping and use of enema, "but in the course of the morning he became quite rational and conscious." He did not know where he was till 9 A.M. of the following day. Still "he was very stupid for some time," and said that "he felt very queer still, and his head was giddy." He then explained that he had for some time before been "giddy if he stooped." "He had been feeling giddy for fourteen days, after lifting a weight; when he rose up his head would swim for a time. The day before the night of his attack, he had been at work at the station from 1 P.M. to midnight; he had felt poorly, and had taken some brandy twice; was going home when he became insensible. The last thing he remembers was getting another porter to take his list to the office. He did this because he found himself getting worse,—more giddy and stupid." Mr. Jones gives it as his opinion that the case indicated "a disorder of febrile and catarrhal nature," leading to impaired cerebral power. Besides the possibility of a weakened condition under influenza, account must be made of over-work, probably lifting too heavy weights, and to these must be added aggravation of cerebral excitement in the turmoil of station work. Twenty-three days after admission he is reported, "going on quite well, —only very weak." Soon after, he left the hospital, but came back about a month after as an out-patient, and so continued for several weeks, and then went to the country for a time, and is reported on June 15 as at work and gaining strength. He never had a return of the unconsciousness, with cerebral paralysis.[1]

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[1] Abercrombie's *Intellectual Powers*, 12th ed., p. 239.

A case more exactly presenting the conditions of what is commonly named trance is the following,—Case 12 in the series given by Mr. J. Handfield Jones, and named by him "Hysterical Trance." It is the case of a female, aged seventeen, of whom he says that "she was a healthy girl," and "never had any epileptic fits." She had been attacked on the evening of the 20th October 1870, and Mr. Jones saw her on the following morning about 11 A.M. When the attack came on, "she had been up-stairs, and on coming down shrieked out and became insensible." She continued "quite insensible and motionless" for about twenty-six hours, when she seems to have come out of the unconscious state as suddenly as she had passed into it. "She asked for and drank some tea, and ate a little bread and butter, but soon relapsed into her former state." Liability to pass into the trance continued for some weeks. Several times in the course of a day she would become conscious, and appear as if nothing were wrong, and yet soon pass again into insensibility. About a week after the first attack she "became delirious, had delusions, and struck the walls with her hands." This was an unusual experience. When in the unconscious state there were "no convulsions," but at times "her arms and legs were rigid." When in this state during a visit made by Mr. Jones the following facts were noted :—"No effect is produced by tickling the soles of the feet; she seems quite unconscious. Her eyes are wide open; touching of the eyelashes causes no winking of the lids, and touching the sclerotic (see above, p. 61) very little, but touching the cornea causes immediate closure of the lids. The pupils are of medium size, and seem insensible to light."[1] In course of a few weeks recurrence of the trance ceased, but a year and a half afterwards there was a brief period during which the abnormal state of things returned. Mr. Jones refers the case to "hysteria," and in explanation of the facts occurring in the life of an apparently healthy girl, "active and useful in the household," and not presenting any features of temperament or habits of life "such as would lead one to anticipate the occurrence of hysterical disorders," he says that "a cataract which subsequently appeared probably indicated some inferiority of the nervous system." Three members of the family seem to have suffered from their eyes, and Mr. Jones concludes that the trance state may have been a consequence of "developmental affinity of the eye and of the brain." The case is one of a class not infrequent, and is of much value to those studying the relations of mind and brain. There is complete coma, showing a torpor of the great nerve centres, and also of the spinal centres, and at times nerve excitement throwing the muscles into a rigid state. And this nerve prostration is not associated with any dulness or stupidity when consciousness returned, as there was in the preceding case. "Her faculties were then and at other times perfect; in fact her friends say that she seemed shrewder and keener than usual."

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[1] *Medical Times and Gazette*, 1874, vol. ii. p. 130.

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[1] *Medical Times and Gazette*, 1875, vol. ii. p. 184.

A third phase of abnormal condition of the nerve system is presented by the "*mesmeric sleep.*" This is an artificially induced sleep, in which the patient is unconscious of all around, save that he is completely under guidance of the operator. Experimenting with the "mesmeric sleep" was a favourite occupation with the students who gathered in the drawing-room of the late Sir W. Hamilton while he was Professor of Philosophy in Edinburgh University. By a series of passes made with both hands of the operator, which are brought from above the head down over the eyelids, and are returned by a slightly curved movement behind the back, a state of artificial sleep is induced, out of which the patient is brought by a reversal of the passes, that is, from below the face upwards, with occasional blowing upon the eyelids. This sleep is as readily induced by concentrating attention on a coin in the palm of the hand, without resorting to any passes. During the "mesmeric trance," the excitement in many cases becomes great, the pulse sometimes rising to 120 in a few minutes. Frequent submission to the influence tends to induce an abnormal condition, and by-and-by establishes a dominion of a most pernicious kind, which is not readily broken. The tendency to yield to the influence increases at a rapid ratio. Hence it is that public operators are pleased to have the same persons to operate upon from night to night.

The "mesmeric" trance is in one aspect an artificial sleep; in another an abnormal condition of brain analogous to the unconsciousness of the trance state described above; and in another aspect still, completely differing from the trance, inasmuch as there is an established relation between the operator and the patient, making it easy for the former to communicate with the latter. It is a voluntarily induced state, for though the person is thrown into the trance by means of the passes made over the head, the result is accomplished only if he voluntarily yield to the influence. By determination to the contrary, turning the attention away from what is done, and concentrating it on something contrary, the most resolute efforts of the mesmerist prove fruitless. In further illustration of this, a person may, by no other influence than his own, throw himself into this trance, which in such a case would continue in the form of a natural sleep. The unconsciousness belonging to the "mesmeric" trance is one which seems to affect the sensory system more than the motor. There is at times natural flexibility, at others rigidity of the muscular system; and susceptibility to pain seems considerably diminished. Observation of those in the state makes it difficult to decide whether there is an actual insensibility to pain, or a disregard of it under excitement, in accordance with well-known facts in the ordinary waking state (see p. 409). There is unusual sensibility to the influence of the operator, the degree of which, however, varies, being much greater in the case of those of excitable temperament. The power of the operator is such that his words carry conviction, and convey impressions of the most vivid order to the patient. While the latter is as oblivious to all around him as if he had fallen asleep in his chair, the mesmerist can communicate with him as freely as any one may with the somnambulist, as in the case described above (p. 439). Under the representations made by the operator, the mesmerised person shows great quickness of imagination, associated with great susceptibility, which strangely contrasts with the insensibility to touch. The operator, placing a tumbler of water in his hand, may tell him that the water is very cold; he will taste it, and admit that it is so. If he be next told that it is getting colder and being frozen, he will appear to recognise it by the touch, and will visibly shiver. If it be now suggested that the water is growing warm, he will appear at once to feel the change, and will state that he does. If it be further declared that the water is now growing very hot, he will get out his pocket-handkerchief, and wrap it around the glass to save him from having his fingers burned. If it be said that the water has begun to boil, he will scream and throw the glass from him in alarm. Such phenomena as these help to illustrate the vividness of imagination often characteristic of our dreams. The mind which, at the mere suggestion of another, can vividly represent to itself such sudden and violent changes as those described, and thereby awaken sensory impressions, can do the same for itself without direct suggestion from another. The mind which in such slumber is capable of interpreting what is said, is capable also of carrying out its own lines of thought, utilising the power of imagination to suit the present exercise, and operating upon the sensory centres, just as in the somnambulistic excitement it acts upon the motor centres. Thus the mesmeric phenomena, taken with those of somnambulism, illustrate the fact that clear and consecutive intellectual action is compatible with what we describe as a state of "unconsciousness." A theory of mesmeric influence it will be exceedingly difficult to construct. The mesmeric trance belongs to the class of obscure nerve affections of an abnormal kind. The state is such as to involve "unconsciousness" in some degree, along with "consciousness" of certain phases of activity; but the patient comes out of the state without any recollection of what has been said and done. Investigation into the facts is thus seriously restricted. In acknowledgment of this it seems reasonable that no special argument in support of the distinction between mind and brain should be founded upon them. But this much they do illustrate, that active intellectual exercise is compatible with the state of sleep, and nevertheless the agent may have no recollection of his doings when he awakes from his slumber. For the results of more extended observations as to the nature and testimony of hypnotic experience, readers are referred to the Appendix added to the present edition, p. 519.

CHAPTER XIV.

BRAIN DISORDERS.

THAT a complicated organism like the brain must be exceedingly liable to disorder, and that such disorder, when it appears, is a purely physical disorder,—a disease of the tissue,—or restraint on its action, are considerations which must be acknowledged universally. As, however, it is admitted that the brain is the organ of mind,—and this is expressly maintained by those who hold the distinct nature and higher functions of mind,—all disorder or disease of brain must present facts of importance towards constructing a theory of the relations of mind and brain. The disturbed state of the brain, with all the physical and mental peculiarities which appear in consequence, must throw great additional light on the functions of the brain and the scientific interpretation of mental phenomena. The Pathology of the Nerve System is, therefore, a department of study specially important to the psychologist.

From what has been already said as to the action and reaction of mind and brain, it is clear that any disorder affecting the brain must, according to its nature and extent, affect the mind. In cases of slight disturbance, the effect may not be such as to be marked in the consciousness of the individual himself, and may not attract the notice of any observer, but every change on the cellular substance of the nerve centre is a change relatively to the mind of which it is the organ. Every check on the functional activity of the organ must have a bearing upon the possible activity of the mind in its government and use.

These very obvious positions may suffice to indicate that the work of the pathologist concerned with the treatment of those suffering from brain disorder is intimately related to the whole subject of study here under consideration. At the same time.

it is needful to remember that the pathologist is dealing with a physical disorder, and is seeking the cure of physical disease, as truly as any specialist in the medical profession who has devoted himself to the study and treatment of diseases of the lungs, the heart, the stomach, or any other organ. When, however, we speak of the pathology of brain, the organ is so closely connected with the mind, that there is special risk of obscuring the fact that, as in the other cases named, we are dealing with physical phenomena. We have come even systematically to speak of "mental diseases" and their treatment, as if the phrase were the appropriate designation in the circumstances. Yet it is singularly inappropriate, except in the vocabulary of those with whom brain disorder and disorder of mind are synonymous. The closeness of relation between mind and brain,—the admitted fact that disturbance of the one, as a rule, involves disturbance of the other,—may sufficiently account for conventional usage. But the power of conventionalism is the only explanation of the persistence of the phrase "mental diseases," to describe a class of disorders as truly physical as disorders of the eye or ear. Every one devoted to the pathology of brain must, indeed, take account of mental phenomena as throwing light upon the probable condition of the organ entirely concealed from his observation, yet for the relief of which he must prescribe. No oculist would disregard the statement of a patient who mentioned that he often saw luminous appearances floating before him. No aurist would treat slightly the statement made in consultation that the patient experienced uneasiness and inability to understand what was said when words were loudly spoken. And, on precisely analogous grounds, the physician dealing with morbid conditions of brain, must mark and classify evidence as to the feelings, dispositions, and thoughts of his patients, which have a distinct value for his purpose, if only they are accurately interpreted. If he is dealing with an organ whose recognised function it is to convey impressions to the mind,—an organ which is, as Feuchtersleben said, "the focus of represented images," and "essential to the manifestation of psychical action,"[1] he must concentrate a large portion of inquiry in each case on the experience and action of the mind, in order to reach an accurate diagnosis of the condition of the brain. This then indicates the true relation of two distinct orders of facts, known by completely different methods, a relation which quite readily explains the general tendency to speak of "mental diseases," and even to employ the phrase in academic and scientific usage, though it is recognised that express reference is made to brain disorder or restraint. There is nothing in the usage which carries a single tribute of *prima facie* evidence for the theory that mental phenomena are merely manifestations of organic action. The distinction and relation of the two orders of facts has been well stated by Dr. Ferrier in these words:—"It is essential to bear in mind that the functions and diseases of the brain manifest themselves under two aspects—the psychological and the physiological: phenomena which appeal to two distinct methods of investigation—the subjective and the objective. . . . That the brain is the organ of mind no one doubts; and that, when mental aberrations, of whatever nature, are manifested, the brain is diseased organically or functionally, we take as an axiom."[1] If there is defect of the optic nerve involving a measure of colour-blindness, the mind must be proportionally restricted,—we often say "misled,"—as to distinction of colour, but there is not in this any proof of deficiency in mind. If deficiency or disorder extend higher up on the nerve centre, the relation of facts is in no degree altered,—there is a physical basis to account for the disturbance, but it is not thereby shown that there is a disorder of mind. On the contrary, we may have clear evidence that the mind deals accurately with the circumstances. The man restricted in discrimination of colours is not only observed by others to be defective in vision, but the fact is known to himself, and his judgments of colour are voluntarily adapted to the recognised defect. And just so it is that, when more serious brain disorder threatens to carry disorder into the mental processes also, the patient observes the fact, and adopts means to ward off the threatened danger, or to guard against acting under misconception. We may, on the ground of evidence already adduced, indicate the point from which we start our investigation of pathological facts, thus,—any degree of injury to the nerve centre may imply disturbance to the mind, and the greater the injury of the organ, the greater the disturbance to the mind, of which it is the organ. Or, to put it from the physiological point of view, and apart from polemic interests, we may take the words of Dr. Brown-Séquard, when speaking of the "grey matter of the upper part of the brain:"—"You may subtract from this, by disease or otherwise, say the upper third, and still you have the nerves and the nerve cells, and the processes can be carried on; but in the progress of such destruction downward there would eventually be reached a point where the functions of the brain could no longer exist."[1] Such a hypothetical method of diminishing the quantity of cellular substance does not in any way illustrate the ordinary history of disease in the organ, nor does it satisfactorily meet the problems as to "localisation," but it puts in a clear light the introductory consideration which must influence all our study of pathological evidence.

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[1] *Medical Psychology*, translated for Sydenham Society, p. 105.

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[1] *The Localisation of Cerebral Disease*, p. 5.

Without attempting an exhaustive classification of the facts, or considering the subdivisions which have been suggested by the various authorities on brain disorder, the purposes of the present inquiry may be met by a threefold distribution of the phenomena. These may be stated thus:—1. Imperfect development of the organ; 2. Disease of greater or less extent in the brain; 3. Violent injury to a healthy brain. The classification is not sufficiently exhaustive to include the vast variety of cases which come under professional treatment, but it marks clearly distinguishable classes, and meets the requirements of the present investigation. The first class includes cases of imbecility apart from disease; the second, cases of insanity, with mania; the third, cases of suffering and restraint in mental activity, without insanity.

I. *Imperfect development of brain.*—It has been already remarked (p. 22) that when the brain falls below 30 ounces in weight, there is imbecility, and it is to be noticed along with this, that where there is such an undeveloped nerve centre, there is feebleness of body as well as "feebleness of mind." Accordingly the muscular condition, as truly as the range of mental activity, is an index of the state of the brain. It even becomes an obvious subject of inquiry whether the half-developed physical condition, recognised equally in the nerve system and in the muscular, is not the explanation of those facts which we describe by the current phrase "mental weakness." Quite appropriately, from this point of view, it has been remarked by Dr. Maudsley, as the result of long observation in this department, that "the superiority of the human mind over the animal mind seems to be essentially connected with the greater variety of muscular action of which man is capable: were he deprived of the infinitely varied movements of hands, tongue, larynx, lips, and face, in which he is so far ahead of the animals, it is probable that he would be no better than an idiot, notwithstanding he might have a normal development of brain."[1] Undeveloped brain implies an undeveloped physical condition; such a condition implies the impairment or loss of many of the appliances which contribute to intellectual development. On the other hand, if large use of muscular action be a condition of normal mental development, mental power is a prerequisite (see p. 298) for accomplishing the "greater variety of muscular action of which man is capable." Such facts, lying on the threshold of the subject, are not unfavourable to the theory that mind is a higher order of being, but readily harmonise with it. If mental phenomena are merely the product of a healthy exercise of organism, "mental weakness" is caused by physical weakness. If mental activity discovers the presence of a power higher than anything which belongs to organism, the "mental weakness" appears in the impairment or lack of the physical appliances in the use of which mind exercises its power, and manifests itself to observers. Thus far, it is obvious, preliminary facts do not bar the way of entrance to this field of inquiry against either of the theories propounded.

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[1] *London Medical Record*, 1874, vol. ii. p. 334.

We thus come to the question, To what extent is imbecility accounted for by imperfect development of brain? At an early stage of this inquiry we have seen that neither is size of brain nor weight a sure test of brain power. Much depends upon quality of the nerve cells, and convolutions of the grey matter.

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[1] *Body and Mind*, p. 30.

But it is beyond doubt that there is a limit, beneath which there is "imbecility." Below 30 ounces in weight,[1] or below 17 inches in circumference of cranium,[2] uniformly implies imbecility.

In the large number of cases of idiocy, only a comparatively small number come under the classification of microcephali, or persons of small brain. This is a fact requiring to be specially remarked. Only a small fraction of the idiocy or imbecility appearing in the history of our race can be traced to imperfect development of the organ of mind. "Idiocy is generally the result of disease, not of smallness of the brain."[3] Several scientific men of France, after thirty years of "measuring and weighing," declared that "three-fifths of idiots have larger heads than men of ordinary intelligence."[4] The simple explanation is, that disease of brain in many cases results in enlargement of head, as at once appears by reference to Wagner's Tables. To the same effect is the testimony of Professor Carl Vogt:—"Cases of microcephaly are rare. The crania and the brain of the microcephali are the most valuable objects in pathological collections. Despite long continued researches, I have, in the whole scientific literature, only found notices of about forty cases, and even of these there are probably some belonging to the category of idiotism from disease."[5] Dr. Ireland says,—"It is the rarest of all kinds of idiocy." After giving a list of 31 cases, Vogt remarks:—"Of these thirty-one cases, nine are of the female sex. In eight other cases, the age of which is unknown, but the sex indicated, there is one female case; there are thus about 25·6 per cent., or one-fourth of the female sex."[6] Dr. Ireland, referring to Vogt's *Mémoires*, says that "many more have been recorded since the publication of his monograph," and adds, "there are nearly twice as many male microcephales as female."[1] "Few microcephales are of ordinary stature, and many of them are mere dwarfs."[2] As a rule, they do not live long. In Vogt's table of 31 cases, only six are above 20 years of age, and there are ten under 10 years of age.

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[1] Turner's *Anatomy*, vol. i p. 298.

[2] Ireland on *Idiocy and Imbecility*, p. 79. For a large gathering of measurements, see *Thesaurus Craniorum, Catalogue of the Skulls of the Various Races of Man*, by Dr. Joseph Barnard Davis, selecting the letter B in each case. Out of this list of 1500 skulls, I have gathered only 4 examples so low as 17 inches. There are 76 set down at 18 inches,—4 European, 39 Asiatic, 4 African, 2 North American, 13 South American, 10 Australian and Islands of the South East, 4 natives of the Western Pacific Isles.

[3] Ireland's *Idiocy*, etc., p. 79.

[4] *Seguin's Report*, *Ib.* p. 78.

[5] *Anthropological Review*, vol. vii. p. 129.

[6] *Ib.* p. 135.

While, then, the imbecility arising from a small size of brain is comparatively uncommon, there are, nevertheless, examples sufficiently numerous to guide us to definite conclusions. When dealing with the comparative structure of brain in the ape and in man, it was shown (p. 161) what is the contrast between the ape's brain and the undeveloped human brain. There is, therefore, no need for discussion of the subject at this point. Restricting attention here to the cases of undeveloped brain in the human race, there are very striking contrasts presented in the several examples. This is well illustrated by two cases reported from Italy, the one girl being named Antonia Grandoni, the other Cioccio, which may be readily compared, being reported upon by the same observer, and both present very small weights and measurements, while illustrating great diversities of "mental action." They are reported by Professor Cardona, and a microscopic examination of the brain was made of the case of the former by Dr. Severini of Perugia.[3] The girl upon whose case interest concentrates as the most singular example of microcephaly known, Antonia Grandoni, was born in 1830, and died in 1872. "Her father was a boatman; her mother was a woman of small stature, who died of consumption;" Antonia's brother and sisters were all healthy children. Her brain, when weighed, was found to be only 289 grammes, little more than 9 oz., one of the lightest on record, and a wonderful amount below the boundary line of 30 oz., under which imbecility appears. Comparison with other cases may be made by the following enumeration, reckoning 32 grammes = 1 oz. 2 dr. "Among the cases published, Wagner had one whose brain weighed 300 grammes; Griesinger, one of 576 grammes; Theile, of 294 grammes; Gore, of 283 grammes; Marshall, of 238 grammes. . . . In none of these did the intelligence approach that of Grandoni;

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[1] *Idiocy*, p. 81.

[2] *Ib.* p. 80.

[3] *Ib.* p. 103.

indeed in all these instances the mental power was of the lowest."[1]

The degree of intellectual activity shown by Antonia Grandoni is wonderful, and much greater than that shown by Cioccio, the external circumference of whose skull was less, though the brain was larger. Of Antonia Grandoni, with her 9 oz. of brain, Professor Cardona reports: "She has good sight and good hearing, attends to what is said to her, and gives satisfactory answers; she sometimes smiles, but more to do like those around her than from hilarity. She sets herself to work like any other girl."[2] "She was not much later than usual in beginning to walk and speak, but her intelligence was inferior to children of her age. She, however, learned in time to do easy work about the house, and to go out of doors to buy provisions. She was fond of learning amorous poetry, and showed erotic tendencies. On getting older, she took to wandering about, and might be seen dancing, with grotesque movements, to her own singing. For many years she led a wandering life, an object of curiosity, of pity, or of ridicule to all." In this account there are some puzzling features, but the degree of intelligence stands out as the singular fact in the case. The wandering life allowed to her was a great misfortune, as was the neglect of systematic educational efforts, for there can be little doubt that the fondness for amorous poetry could have been widened out to something greatly more enlarged and elevating. The contrast between the intellectual activity in her case and the almost complete absence of it in the case of Cioccio, is thus dwelt upon by Professor Cardona:—"The smallness of the brain of Cioccio induced stupidity, idiocy, deaf-muteness—in short, simply animal life; the poverty of brain of our Grandoni, in that small size accorded to it by nature, could admit of a sensibility, an intelligence, and an education which has not fallen much short of the average of her countrywomen." This sentence, showing, as it does, a genuine and valuable interest in the case, is apt to be misleading. When we speak of the stupidity and idiocy of Cioccio, we must consider that "deaf-muteness" implies a series of barriers to the development of intelligence. This has been illustrated by the breaking-up of these barriers in the history of Laura Bridgman (p. 380). On the other hand, we can hardly allow, in view of the description, that the intelligence of Antonia Grandoni at all approached the average intelligence of her countrywomen. Without saying so much as this, her intellectual activity is a marvel with a brain of 9 oz. In the case reported by Mr. Gore, also of a female, the brain weighed 10 oz. 5 grains (avoirdupois), or 283 grammes, and that "after the membranes and vessels had been removed." This is only 6 grammes lower than Grandoni. Of the woman to whom Mr. Gore refers, he says, "she could say a few words, such as 'good,' 'child,' 'mama,' 'morning,' with tolerable distinctness, but without connection or clear meaning, and was quite incapable of anything like conversation."[1] The case reported by Professor Marshall is that of an idiot boy who died at twelve years of age, the entire encephalon weighing only 8½ oz.[2] Unfortunately there is not in the report of this case a single remark as to the degree of intellectual activity manifested by the boy.

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[1] Ireland's *Idiocy*, p. 110.

[2] *Ib.* p. 104.

When Antonia Grandoni was brought to the hospital, where she afterwards died, the following results, from regular observations of her conduct, are noted:—"The walk was slow and hesitating; but she was a good and agile dancer. She was gay and sociable in her disposition, and never complained, except for bodily pain, but the idea of death disturbed her. She was always quiet and obedient, and when hindered doing anything, she showed grief, but no resentment. She felt for the suffering of others. She knew that her head was small, and an object of attention. She was very careful in her dress, and was fond of attracting the notice of the other sex. She remembered those who were kind to her, was glad to see them, and would go in search of them when they did not appear. When visitors came to the hospital, she desired to be noticed, and was disappointed if she were neglected. She was fond of talking about marriage, liked singing and dancing, could play well upon the cymbals, and was anxious to get her companions to dance to them. She showed a good memory for names of persons and things, remembered places and bygone events, but had no memory of time. She answered questions satisfactorily, adding information without being asked. She had the sentiment of good and evil, and made sensible remarks upon the conduct of her companions. She was religious through imitation and habit, and behaved well in church. Every attempt to instruct her was without success."[1] In view of this narrative, there is no room to hesitate as to Dr. Ireland's statement: "I have little doubt, by a well-planned education in childhood, her mental power could have been increased and her wandering and erotic tendencies repressed." As little room is there for questioning the following:—"Any one who compares the cranial capacity of a few microcephalic idiots with the intellectual manifestations, will hardly fail to notice that the one does not bear any definite proportion to the other."[2] If for a moment we recur to recorded brain weights of apes, taking these as given (p. 160), 9¾ oz., 13¼ oz., 12 oz., the force of the remark made by Professor Marshall becomes obvious when he "alluded to the supposed similarity between the brains of idiots and those of the higher apes, and maintained that the objects are not comparable, as the brain of the ape, though low, is perfect, but that of the microcephale is essentially imperfect."[3]

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[1] *Anthropological Review*, vol. i. p. 169.

[2] *Ib.* Appendix, Transactions of Anthropological Society of London, p. viii.

Fortunately we have the results of a careful examination of the brain of Antonia Grandoni, made by Dr. Adriani. In his report, the points of chief interest are the following:—"The hemispheres were the least developed. The pons, the medulla oblongata, the tubercula quadrigemina, the peduncles, and the cerebellum fell much less below the ordinary dimensions. The greatest breadth of the brain at the middle was 85 millimetres, and 68 millimetres at the base of the anterior lobes. The cerebral hemispheres were perfectly symmetrical: they were 100 millimetres in length, and *were shortened posteriorly*, so that the cerebellum was left uncovered for about 70 millimetres. The fissures of Sylvius and Rolando were well marked. All the cerebral lobes were small; the parietal and occipital were smaller in proportion to the frontal and temporal lobes. The sphenoidal and the anterior and posterior central convolutions were also proportionally well developed. The convolutions of the frontal and temporal lobes were more complicated and better developed, and more numerous than those of the parietal and occipital. The most notable anomaly of the brain was a shortening and slight thinning of the corpus callosum."[1] While the hemispheres were the least developed part of the encephalon, their deficiency appeared most to the rear, leaving the frontal relatively conspicuous. This fact harmonises well with the view commonly taken of the frontal region. On the other hand, Bischoff's case,—Helene Becker,—illustrates a comparatively prominent frontal region, with a falling away towards the rear, which assumes nearly the form of an angle, while her intellectual activity was so slight that "she knew her own name, but otherwise paid very little attention to what people said to her. She could only speak one word, but used two sounds."[2] The remark as to the corpus callosum deserves notice, but over against it we must place the case reported by Professor Malinverni, of the University of Turin, which is that of a man, aged forty, "who during life had shown no signs of alteration or deficiency of the intellectual faculties," yet, on examination of the brain, it was found "that the corpus callosum was entirely wanting, together with the septum lucidum, and the great cerebral convolution which surrounds the corpus callosum." The cerebral mass, when viewed externally, did not present any peculiarity," but "the convolutions at the base were indistinct, specially those of the frontal lobe."[3]

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[1] Ireland's *Idiocy and Imbecility*, p. 106.

[2] *Ib.* p. 112.

[3] *Anthropological Review*, vol. i., App. p. x.

The microscopic examination of the brain of Antonia Grandoni by Dr. Severini brought out the following results:—"No remarkable difference was found in the structure or proportion of the nerve corpuscles; . . . there was a remarkable abundance of fundamental tissue, especially in the cortical matter of the brain, which made the nerve cells appear scarcer than usual; . . . the prevailing form of nerve cell . . . was the triangular one, with an oval or round nucleus,—few displayed the pyramidal form; the structure of the blood-vessels appeared normal; if anything they were somewhat larger than usual."[4]

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[1] Ireland's *Idiocy*, p. 108.

[2] *Ib.* p. 113.

[3] *London Medical Record*, 1874, vol. ii. p. 319.

[4] Ireland's *Idiocy*, p. 109.

The first and last of these statements are favourable to functional activity; the others are obviously unfavourable, and make the intellectual manifestations in the life of Grandoni all the more remarkable.

Grandoni's case cannot be taken as an illustration of ordinary examples of microcephaly; but as a decidedly exceptional case, it has been the subject of special investigation, and is suggestive as to the chief remaining point of inquiry here,—the possibilities of education. The degree of intellectual activity appearing in her case, even under all the disadvantages of her neglected and wandering life, makes it clear that, had systematic training adapted to her mental condition been provided in her youth, she would have led a greatly higher life.

We have now to consider whether, in the case of persons of undeveloped brain, it be possible successfully to prosecute intellectual and moral training. The question connects our inquiry with that previously raised as to deaf-mutism, and is naturally regarded as a continuance, in altered form, of the problem presented by the case of Laura Bridgman (p. 380). In this department our most reliable witnesses are those who have devoted themselves to such educational work. Their testimony is that the work of education has been successfully carried on in a large number of cases. And, what is of special importance here, there is no educationist of experience in this peculiarly difficult but noble department of service to humanity, who suggests that effort should be directed, in the first instance, exclusively on the physical condition. It is a maxim with them all that the physical and mental must go together, involving two entirely different forms of exercise for each day. That is to say, they proceed with physical training as a distinct undertaking, with the view of developing physical powers, muscle, nerve, and brain; and with mental training, as something different, with the view of developing thought, self-government, and self-respect. Thus Dr. Edward Seguin, in his work specially devoted to an exposition of the "physiological method," and as the result of large experience both in France and America, has insisted on this, devoting one part to "physiological education" and another to "moral treatment,"—"the alliance of the moral and physical sciences," as had been urged in the report to the Academy of Sciences of Paris by MM. Serres, Flourens, and Pariset. Dr. Seguin treats of the physical as tributary to the mental, as indeed it must be in all human life:—"Let it be one of our first duties to correct the automatic motions, and supply the deficiencies of the muscular apparatus; otherwise how could we expect to ripen a crop of intellectual faculties on a field obstructed by disordered functions?"[1] "Our system of education is the process of accumulating in children strength and knowledge; to create in men power and goodness."[2] While warning against "one-sided education," he remarks on the special need for developing nerve power rather than muscular, "paying more attention to the nervous, as being the most shattered in idiocy."[3] On the other hand, Dr. Seguin insists: "Whatever we want a child to do, and whatever might be otherwise our special teaching to that effect, there are certain moral conditions as necessary to our success as the technical ones."[4] "Moral training of the children, one by many, several by one, all by all, is one of the mainsprings of the present part of our task."[5] "Our authority over them does not derive from our superiority, but from the desire of elevating them to our standard."[6] Dr. Ireland is equally decided:—"The treatment should be both mental and physical;" "to produce improvement we must act upon the whole being, upon the body as well as the mind."[7] The wants of the imbecile cannot be met by concentrating effort on improvement of the physical condition first, with the view of attending to the mental afterwards; nor by attempting to instruct the mind, to the neglect of physical development. Hence the force of Dr. Ireland's testimony:—"It would seem at first sight that a private teacher, such as a governess, who had the entire tuition of an idiot child, would come to her task with great advantages on her side, as she could devote her whole time to one pupil; but nevertheless, I do not remember ever to have heard of much being done in this way."[8] Very naturally does it follow upon *one-sidedness* of treatment, that the remark should be made: "It may be doubted whether it is a sadder sight to see the neglected idiot children of the poor, or the pampered idiot children of the rich."[1] If an imbecile child is simply fed, clothed, tended, and taken out for airing, he is allowed to vegetate. He is tenderly cared for, yet is most seriously neglected. Improvement will never come under this system; the hope of it has been surrendered. In this connection, I have read nothing more affecting than the words of Dr. Langdon Down, Physician to the London Asylum for Idiots:—"I have seen the relative of a noble, living in all the luxury of a country house, so put aside by her sisters, senior as well as junior, that she never ventured on a remark, and at length lost speech. I have seen the same girl at Normansfield pass from monosyllables to thorough conversational language amid the companionship and sympathy of her compeers."[2]

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[1] *Idiocy, and its Treatment by the Physiological Method*, by Edward Seguin, M.D., p. 94.
[2] *Ib.* p. 97.
[3] *Ib.* p. 99.
[4] *Ib.* p. 217.
[5] *Ib.* p. 218.
[6] *Ib.* p. 220.
[7] *Idiocy*, p. 294.
[8] *Ib.* p. 296.

In closing this line of evidence, it seems clear that the facts connected with microcephaly or undeveloped brain, and education of the imbecile, favour the view that mental existence is something superior to brain organisation, though in all human life the two are intimately connected. The general results may be summarised in two or three sentences. 1. Very few of the human race suffer in consequence of an undeveloped brain. The great majority of instances of imbecility are to be assigned to disease. 2. In cases of undeveloped brain, we do not find a robust animal life with a feeble mental life, but feebleness of body as well as "feebleness of mind," which last might better be described in the words of Dr. Edward Seguin as a mind "obstructed by disordered functions," a mind undeveloped through lack of opportunity for its exercise under the ordinary conditions. 3. Education of the imbecile is possible, notwithstanding organic restraint. If physical and intellectual training are carried on together, the results are mutually helpful, the advancing mind aiding development of body, and improved physical condition opening the way for wider and more complex use of intellect. The methods employed are distinct. On the one hand, there is comparison, classification, reasoning; on the other, food, air, and muscular activity.

II. *Disease of Brain.*

The brain is liable to disease, as every bodily organ is, and such disease should be regarded as a natural and inevitable consequence of the interdependence of physical organs. The designation, "mental diseases," has had a misleading and pernicious influence upon the public mind. It has been allowed to circulate, as if it carried the suggestion that the sufferer had "lost his reason," and was no longer within the circle of rational beings. That a friend suffers from brain disease no more affects his position as a man, or our relation to him, than if he suffered from disease of the heart or of the lungs. The brain is in many respects more liable to disease than other vital organs, being so much more under the command of our will, and liable to be overtasked. It is an irrational view of brain disease which leads any one to regard it otherwise than as a physical disorder, more or less serious according to the extent of the disease and the hold it has obtained on the organ. That there may be great moral culpability in the conduct which induces such disorder is not to be overlooked and cannot be denied, when the statistics of our asylums show that at least one-third of the cases are to be attributed to drunkenness and a licentious life. But, on the other hand, brain disorder may be induced by natural causes as readily as any other form of disease, and, like every other disease, may assume a curable or an incurable type. When curable, the cure is effected primarily by medical prescriptions, aided by suitable regimen, as in all cases of physical disorder; when, however, the patient is amenable to reason, "moral means" are employed in acknowledgment of the essential superiority of personal control.

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[1] *Idiocy*, p. 297.

[2] *Ibid.* p. 299.

As it is granted by all that brain is the organ of mind, brain disorder must affect mental experience. Certain forms of disturbed personal experience must be the indication of incipient brain disease, while emotional disturbance is perfectly compatible with a healthy condition. In harmony with the former of these statements, it must be observed that in like manner it is from personal experience that evidence can be gathered as to heart disease and disorder of the stomach or the liver. "How one feels" must be the question. Disturbed experience is a common feature when subjected to disease. The speciality belonging to brain disorder is, that it not only involves experience of uneasiness and restraint upon the great nerve centre, but disturbance of mental processes. This fact seems in strict accordance with the view that mind is an order of existence higher than brain. If brain be the organ of mind —the organ through which communication is carried to the mind, and through which also communication is conveyed from the mind—it follows that disorder will disturb the communication; extending disorder will even gradually shut off the communication, as the disease advances towards a fatal issue. The matter of interest here is, the extent to which the phenomena connected with a disordered condition of brain throw light on the relations of mind and brain.

Disorder of brain may arise from many causes, of which the following may suffice as illustrations;—insufficient blood supply, inducing feebleness and brain wasting; excessive blood supply, causing pressure and uneasiness; febrile excitement or inflammatory condition of the tissue; pressure, as by formation of a tumour or accumulation of fluid; or inherited instability of brain organisation, rendering its tissue liable to take on morbid action.

A brief description of some of the conditions of brain as they appear after death in the case of those whose physical and mental state was recorded during life, is the best introduction to this part of the subject. I am indebted to Dr. Clouston, Lecturer in the University on Mental Diseases, and Superintendent of the Royal Asylum, Edinburgh, for special facilities for comparing pathological phenomena. The following cases are selected as illustrative of different phases of disorder:—1. A considerable portion of the brain shows signs of wasting, and the membrane (*pia mater*) is adhering to the brain, thereby showing interference with the nourishment and normal condition of the organ. This is a very common phase of diseased brain. 2. Brain of a young woman who died at twenty years of age, and had been a sufferer from epilepsy. One hemisphere of the brain is well developed, the other is quite undeveloped, so as to be hardly one-half the natural size. She was very liable to epileptic fits, under which, as Nothnagel puts it, two symptoms may be regarded as essential—"*first*, the mental disturbance, which generally manifests itself as a more or less distinctly marked loss of consciousness; *second*, motor disturbances, under the form of more or less extensive convulsions."[1] 3. A brain in which wasting of a portion of the parietal lobe is manifest, leaving a considerable blank space in the grey matter, and a darkish spot just beneath, as if foreboding the extension of the malady. 4. Brain in which the wasting appears in the white substance, which is a more unusual occurrence. In this case the wasting has extended so greatly that only slight portions of the white matter remain, and yet the person had been able to move the limbs to some extent. 5. A brain in which serious traces of wasting are seen in several places; the membrane is adhering to the grey substance, and the blood-vessels are hard and strong like quills. This is a case in which loss of self-control was a marked feature. The sufferer had been a clergyman, and had been subjected to ecclesiastical discipline on account of inconsistency of conduct. In the asylum self-government was established only by the action of fear, a series of penalties having been strictly applied in case of failure to conform to the rules laid down, and of these that which made the most impression was the withholding of tobacco. These five cases may be taken as marked illustrations of the condition of brain in persons said to be suffering under *mental derangement*. Disease has been established in that organ, by means of which alone it is possible for the mind to control and govern bodily actions and tendencies.

If this be a description of the facts in such cases, as disclosed by examination after death, all that has been recorded as to the intellectual, moral, and physical aspects of the disordered life of such sufferers can be adequately explained on the theory which regards mind as a higher order of being controlling physical organism in its normal condition, and so determining the whole range of physical activity distinctive of man as an intelligent being. The more carefully we classify, distinguishing in detail the several phases of restraint as they appear, and the intellectual activity of the patients suffering under these, the more obvious does it become that the facts are such as cannot be explained on the hypothesis that brain is the governing power in life. A rigid attempt to give a scientific explanation on such a basis must show not only how truly the disordered brain of the imbecile accounts for the imperfect utterance, the feeble locomotion, and the comparatively slight interest taken in things around; but how it can account for the recognition of persons well known, the interest which their presence awakens, *expectation* of their coming, and the readiness with which the sufferer adapts to his own modes of thinking the suggestions offered by others. Or, to take the opposite class of cases involving mania, a scientific explanation which seeks to trace all to brain, must account not only for the physical restlessness, the excitement, the fear, and the violence which appear, but also for the purely imaginary, and yet rationally consistent, account the sufferer gives first to himself, and then to his physician, of his state of excitement. We require a scientific account of premonitions, so interpreted as to induce the sufferer to warn others to keep off, showing a desire to avoid their injury; of the interpretation of excitement by representations of having been pursued or attacked; of the measures resorted to by the sufferer in accordance with the rationalised account he gives of his own trying situation; and of the possibility in such circumstances of a measure of control being maintained under *expectation* of loss or penalty, if control be surrendered. The combination of facts which will suffice to guide the physician in his treatment of cases will not meet the requirements of a scientific inquiry as to the relations of mind and brain. The physician is concerned with appliances for nourishing the cerebral tissue, for soothing the organ, and for stimulating its functional activity. He is at the same time occupied with favourable mental action as affording an essential feature in treatment, and is thus led quite directly and regularly to take account of mental phenomena. Still, this is done necessarily with a regard to the relation of mental states to physical conditions, and not for the purpose of constructing a scientific account of mental activity, as that is restrained or stimulated by pathological conditions. Even scientific works on the treatment of the insane are not scientific treatises on the action of mind as affected by pathological phenomena, but rather on brain disorder as more or less affected by mental states. This arises from the nature of the case, and must be recognised if there is to be thoroughness in treating of two distinct scientific problems. The theory of brain disorder is not a philosophy of the facts of mental activity observed and classified in cases of cerebral disease. And so, in like manner, a philosophy of mental activity under such pathological conditions would not be a theory of brain disorder, and would not be entitled to consideration as such from those who are engrossed in practical treatment. This distinction will, I believe, be readily acknowledged by medical authorities daily familiar with the details involved in management of our invaluable retreats for sufferers under cerebral disease. The distinction must be marked as quite essential to the investigations involved, indicating the limits of medical and mental inquiry, and the extent to which two departments of study may contribute to each other's advance. In view of this distinction, special value attaches to investigations of a wider kind, on the medical side, involving the relations of the two departments, such as those prosecuted by Brodie, Holland, D. H. Tuke, Elam, Maudsley, and others.[1]

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[1] Ziemssen's *Cyclopædia of the Practice of Medicine* (translation), vol. xiv. p. 266.

In acknowledgment of the twofold problem, it is desirable to consider in one line the facts which are specially connected with the cerebral condition; in another, those which throw light on mental experience.

Facts illustrating disordered cerebral condition.—Reference has already been made to the fact that a comparatively small portion of the imbecility which exists can be traced to undeveloped brain; by far the greater portion of it resulting from the action of disease. In explanation of the latter, much is to be attributed to hereditary influences. The testimony of facts is strong on this point. Dr. Maudsley has said:—"Idiocy is, indeed, a manufactured article; and though we are not always able to tell how it is manufactured, still its important causes are known and are within control. Many cases are distinctly traceable to parental intemperance and excess. Out of

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[1] Brodie's *Psychological Inquiries*, 2 Parts; Holland's *Essays*, and *Chapters on Mental Physiology*; D. H. Tuke's *Influence of the Mind upon the Body*; Elam's *A Physician's Problems*; Maudsley's *Body and Mind*.

300 idiots in Massachusetts, Dr. Howe found as many as 145 to be the offspring of intemperate parents; and there are numerous scattered observations which prove that chronic alcoholism in the parent may directly occasion idiocy in the child."[1] Here then we have idiocy in a large proportion of cases proved to be an inheritance of physical infirmity, on account of physical indulgence on the part of one or both of the parents. It is not shown to be the result of neglected education, or a consequence of leading a wandering life in separation from the intellectual influences of civilisation. If only the physical nature be vigorous, there is an absence of the distressing manifestations of imbecility ; but, notwithstanding a robust physical constitution, there may be in multitudes of cases evidence of an undeveloped mind, for which educational appliances alone are required. Children may inherit a degenerate organism or a highly developed brain; but in no case do they inherit parental ignorance, as they do an enfeebled body; nor do they inherit the intellectual acquirements or knowledge of their parents, as they may inherit physical aptitudes. The question of heredity is still involved in so much obscurity that we are not in possession of facts needful for a scientific explanation, but such wide general data as those now referred to in the history of idiocy are universally admitted by all engaged in classification of cases under their own observation. If to the examples of physical deterioration in the line of inheritance we add cases of imbecility occasioned by accidental injury of the head, and those following upon severe disease of brain. we include almost the entire body of facts bearing on weakness or atrophy.

If from imbecility we pass over to the other side of experience, where the phenomena of active insanity are under observation, we find here also that physical agents and excesses are to a large degree causes of mania. In fact, mania in the drunkard or debauchee is the preliminary in personal history to imbecility in the history of his offspring. Happy indeed are the children of such parents who have been born before parental profligacy had reached its climax. Here, in outline, is the sad history, as quoted by Dr. Maudsley from Morel, who had traced "through four generations the family history of a youth who was admitted into the asylum at Rouen in a state of stupidity and semi-idiocy." In the case of the great-grandfather, "immorality, depravity, alcoholic excess and moral degradation,—killed in a tavern brawl." In the case of the grandfather, "hereditary drunkenness, maniacal attacks, ending in general paralysis." In the father, "sobriety, but hypochondriacal tendencies, delusions of persecutions, and homicidal tendencies." In the youth himself, "defective intelligence, mania at sixteen, stupidity, and transition to complete idiocy."[1] Such is the record of what alcohol and vicious indulgence accomplished within four generations. In accordance with these facts we find the annual reports of our lunatic asylums testifying that intemperance and sexual irregularities and excesses are the chief sources of insanity, and that a smaller proportion of existing insanity is to be assigned to the disease and accidental injury to which organism is naturally exposed. In the *Psychological Retrospect* of 1874, drawn from the annual reports of all the asylums in the country, as given in the *Journal of Mental Science*, July 1875, we read:—"Most reports make reference to the part which intemperance plays in the production of insanity. The time must be drawing near when this horrible vice will be combated in a more efficient and earnest manner than in time past. No one can deny that drunkenness is the great sin of this country, and that to its influence a very large proportion of insanity must be more or less directly attributed."[2] Turning to the next number of the same Journal, we find the President's address to the Medico-Psychological Association, at its annual meeting in 1875, by Dr. Duncan, President of the College of Physicians, Dublin, in which we have the following declaration bearing upon the increase of insanity:—"In my opinion, the monster evil of intemperance, with its associated vices and its accidental accompaniments, is the greatest of all the causes producing the estimated increase. Sometimes it is alone account-able for the overthrow of reason; on other occasions it aggravates and intensifies other causes operating along with it."[1]

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[1] *Body and Mind*, p. 44.

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[1] *Mind and Brain*, p. 45.

[2] *The Journal of Mental Science*, published by authority of the Medico Psychological Association. Edited by Dr. Maudsley and Dr. Clouston. July 1875, p. 301.

If next we pass from the causes to the manifestations of disorder, we have a large proportion of physical results. Within the cerebrum itself we have the marks of brain wasting, indicated by such cases as those given above. In connection with well-known symptoms of this state, we have more or less extended paralysis of the motor, and also of the sensory nerves. Thus, on the physical side, we have marked loss of physical power. No one proposes to deal with these disorders by educational appliances. When, on the other hand, an experienced physician, such as Dr. J. Crichton Browne, tells us of the value for checking brain-wasting and reinvigorating the organ, of such things as cod-liver oil, hypophosphites of soda, tincture of opium, and sulphuric ether,[2] he testifies that a physical malady is under treatment. And when he adds these words:—"Along with the medical treatment of brain-wasting, dietetic and *moral* treatment must be carefully attended to," the reference to "moral treatment" points to another class of facts differing from the physical.

Besides the general fact of paralysis consequent on brain-wasting, we have more specific knowledge which points to the localising of the disorder. This is an essential feature in this class of observations. The locality of the disease has a direct relation with the locality of the paralysis. There is not the slightest diversity of opinion as to this, however much medical authorities may differ as to localising of functions in the cerebrum. A certain amount of localising is recognised on all hands. We have the sensory bulbs, and the basal ganglia, about which there is no dispute, besides the lobes and distinguishable convolutions of the cerebrum. Hence Dr. Bastian has said: "We ought always to endeavour to discriminate the effects of injury to these several parts, since variations in the seat of the lesion give rise to so many of the differences in the total grouping of symptoms daily encountered at the bedside."[3] The obviously accurate, and from a medical point of view, quite essential, method of associating special phases of paralysis with distinct parts of the cerebrum, is another unmistakable proof that we are considering in such cases a purely physical malady. Thus it is made out,—and could never be seriously disputed,—that one large body of evidence demonstrates the presence of disease in the nerve centre, attended by proportionate injury to the sensory and motor system, and as a consequence diminution of muscular strength.

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[1] *The Journal of Mental Science*, July 1875, p. 336.

[2] *British Medical Journal*, 1871, vol. i. p. 468.

[3] *On Paralysis from Brain Disease*, by Dr. H. Charlton Bastian, p. 5.

Facts illustrating mental experience under a disordered cerebral condition.—We have now to pass over to a distinct class of facts, associated with those just described, without which we cannot have a clear view of the evidence bearing on the relations of mind and brain. And here we must have some regard to the *absence* of special mental experience connected with recognised brain disorder, as well as the *presence* of an abnormal experience which testifies to the existence of cerebral disturbance.

Brain disease may exist to a large extent without experience of uneasiness, or indications of mental restraint or aberration.—In many cases of post-mortem examination a diseased condition of brain has been found, where there had been no traces of mental aberration during life. This fact is, indeed, often illustrated, even during life, as has been shown above in cases of paralysis, with unabated intellectual power. Brain disease may assume a very serious form, without restraint on mental activity. Dr. Ferrier says, "that not merely extensive lesions in one hemisphere may be latent as regards mental symptoms, but even a whole hemisphere may be disorganised with a like negative result."[1] The division of the brain into two hemispheres undoubtedly provides for a large amount of normal activity both of mind and body, notwithstanding established disease on one hemisphere. This holds true whether the disorder be on the right hemisphere or the left. The problem thereby raised is a perplexing one for the theory which makes the cerebrum itself the source of all mental action. Given disorder of the brain, how is there not restraint upon mind? It may be said by way of modifying the difficulty that such disease may exist even without visibly restraining motor and

[1] *Localisation of Cerebral Disease*, p. 6.

sensory activity over the body. But if one hemisphere can maintain the efficiency of motor and sensory nerves, this only increases the difficulty by raising the question, Can a hemisphere which is doing double work on the physical side, be at the same time adequate for all that is accomplished by mind? No doubt account must here be made of the fact to which Dr. J. Crichton Browne refers when he says, "It is astonishing how little real thinking will suffice to carry a well-trained man through an average day or month of an average life."[1] But cases of congestion and of brain-wasting, along with acute and powerful mental activity, have been numerous, and even noted as having occurred in the history of some specially devoted to abstruse reflection.

Even when brain disease occasions delusions and mania, there is abundant evidence of the power of accurate reasoning.—The value of facts which may be classified under this division is considerably affected by the locality of the lesion. The injury to brain may be connected with sensory or motor centres, and may but slightly affect those regarded as more immediately concerned with intellectual action. Many examples must be set aside on this account. There remain, however, cases of delusion to which prominence must be given, as they indicate serious disorder of brain. The sufferer under delusion reasons accurately on the suppositions adopted by him to account for his experience. No one would propose to deal argumentatively with his case. His whole intellectual process is in harmony with intellectual law as recognised and applied by others; the delusion is a product of brain state, and can be influenced or removed only by medical treatment. After the delusion disappears, the reasoning process will proceed in acknowledgment of the same intellectual laws as were recognised during the period of delusion.

Evidence of a similar nature may be gathered even from cases of brain-wasting, though here the observations become more difficult, and the facts require more caution for their interpretation. There can be no doubt, however, that intellectual interest can be awakened and maintained when brain-wasting is far advanced. For illustration I may refer to a case which came under my observation when lecturing to more than two hundred patients in our Edinburgh Asylum. In giving some account of American scenery, the description of Niagara was included, at the close of which I had the satisfaction of being catechised by one of the patients, a gentleman well known to me. The dialogue ran thus:—"How long is it, sir, since you were in America?" "About a year and a half." "Oh, but I have been there since then." "Indeed!" "Yes, sir, and the appearance of things is quite changed." "I was not aware of that." "Well, sir, when I was out we drained Niagara, and found in the rocks where the Falls were great quantities of gold, which we had put into bars, and we are coining it here just now." The difficulties of draining Lake Erie were, of course, slight to the listener and thinker who sat on the bench, but he saw clearly enough the engineering, mining, smelting, and coining processes, and regarded them with the interest of one who had given more thought to commercial enterprise than to the beauties and grandeur of nature. Shortly after the period here referred to, the patient had sunk to a condition in which no such interest could be awakened, and ere long was removed by death.

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[1] *British Medical Journal*, 1871, vol. i. p. 442.

Strong Emotion may induce acute brain disorder.—In such cases there is often a constitutional predisposition, either in the sensitiveness of the nerve system, or in the weakness of body at the time. But, on the other hand, the calamity is often occasioned quite as much by the lack of self-government, and a ruling influence which has been allowed to a strong desire or passion. These two classes of influences are so distinct as to involve actual contrast. In the former case the body is weak, and the nerve system highly excitable. A shock to the brain on account of the sudden loss of a cherished relative may lead to mania, and that too in the history of one distinguished for a high degree of reflective and self-governing power. In the latter case the body is vigorous, but self-regulation and quiet self-denial have been little cultivated. A sudden reverse of fortune finds a body strong enough, but a mind ill prepared for endurance of disaster. Bodily health could be easily maintained if the person were allowed to go about his usual avocations, and have his mind occupied and stirred with fair prospects of success; but the bodily health gives way under the burden of a mind which sees the fruit of a life-time of toil suddenly gone, and the life itself change to dreariness. The contrast of the two sets of cases is well known, and does not admit of interpretation under a scheme of human life which traces all its experience to the nerve centre.

Dr. Crichton Browne, when treating of brain-wasting, has marked the contrast, and placed the power of human emotion in an interesting light. He says:—"If mechanical pressure is applied to a motor nerve in such a manner that, beginning with the slightest contact, it is gradually and steadily increased, even until the nerve is destroyed at the point of application, no convulsions or spasms, but only deadness and abolition of function are produced; but, on the other hand, if even a less degree of pressure is suddenly exerted, violent convulsions and agitations inevitably ensue. Now, . . . moral or mental pressure on the brain has two distinct sets of consequences, according to the mode of its application, corresponding with the two sets of consequences of mechanical pressure on a motor nerve, to which we have referred. . . . A sudden emotion—a flash of joy or a pang of grief for which there had been no preparation, and a hastily-imposed intellectual burden,—an arduous task undertaken by an untrained mind, are most likely to produce mania or some acute form of mental disorder; a gradual emotion—pleasurable excitement 'long drawn out,' or a canker care quietly eating its way, and a slowly imposed intellectual burden, the cumulative weight of a course of study—are most likely to produce dementia or a progressive impairment of the faculties."[1]

All treatment of the insane includes a moral element, as well as a physical.—The physician does not content himself with prescriptions and dietary arrangement, with air and exercise. All these are quite essential to health, and their neglect would be fatal. But the physician at the same time deals with the mind by a perfectly distinct method of treatment. This is universally recognised, and moral treatment is accordingly adopted, whether the case be one in which the hope of recovery is great, or one in which liberation from the disorder can come only through death That such moral treatment is always quite clearly defined and rigidly distinguished by the practised physician in his scientific expositions, it is hardly possible to affirm. The physician is so habitually and necessarily occupied with what are more properly a physician's problems, that, as a rule, there is much clearer and fuller exposition of the physical treatment than of moral—of the medicines to be used, the diet to be assigned, the arrangement and ventilation of apartments the enforcing of cleanliness, and the provision for open-air exercise. Advancing beyond this, there is full recognition of the need for cheerfulness on the part of those around, variety of occupation for the patients, amusements, and every kind of soothing influence adapted to the special sensibilities of the patients. But "moral treatment," properly so called, is less clearly defined, and much more briefly described. Nevertheless, it is constantly referred to, and that in a manner which strongly supports this division of the present argument. Thus Dr. Sankey introduces "moral treatment of insanity" as "a very important part of the subject,"[1] and carefully and admirably discusses the old methods of restraint and repression, in contrast with the new methods of non-restraint and encouragement. He says:—"By moral treatment I mean that which is addressed to the patient's mind; in fact to the essential part of his disease. The whole of the principle of this description of treatment is included in one word—in the word Rest; rest to the affected organ, that is, the brain."[2] From the point of view occupied by those who are distinctively analysts of mental experience properly so called, the latter portion of this statement will seem inconsistent with the former. To speak of moral treatment as that which is addressed to the patient's mind, and then to describe it as Rest, seems to suggest a very slight address to the mind. Aristotle found the key of moral life in the opposite word, Energy (ἐνέργεια); and certainly treatment which aims at moral results can reach them only by activity, and that an activity originating from the mind of the sufferer himself, on account of a rational maxim of conduct which he accepts. To seek to promote personal control is an object of the physician in his manifold efforts to secure the recovery of his patient, or even a mitigation of the evils attending on chronic disease of the brain. From what immediately follows in Dr. Sankey's treatment of the subject, it appears that his mind was occupied with an argument against the old method of resorting to force, thus mastering the patient and bringing him to submission under the depressing conviction that struggle is hopeless. All will sympathise with the author in his argument, and will recognise how great a service has been done for humanity by those who have strenuously contended against the reign of force, happily now everywhere discredited and deplored. Very naturally Dr. Sankey gives prominence to rest, as if that single word were sufficient to indicate the character of the whole system of treatment directly opposed to the plan of repression. But, as soon as we pass beyond the dark shadow of the old system, it becomes obvious that "moral treatment" must signify a great deal more than the abandonment of the old, and substitution of everything which contributes to quiet and personal calmness. There should be, and there really is, an effort to carry the patient forward to a reflective exercise favourable to the work of self-control. Just as some degree of self-control begins to appear, is it possible for the physician to recognise evidence of success in his efforts by combination of physical and moral treatment. This is the crowning result, towards which rest can contribute only a proportion of the requisite influence. As Dr. Sankey urges, the physician must "not produce a bad mental effect on the patient;"[1] but must accept the system which "is wholly founded on its mental influence," which "is directed to the pleasurable, and avoids all the depressing emotions."[2] "The aim of the newer system is to cheer, to conciliate the patient, to produce good feeling towards his custodian; to raise, not to depress him, to fill his mind with the pleasurable emotions of hope, love, and thankfulness; to inspire confidence, and which leads him to obey in order that he may oblige, that he may obtain and retain the affection and the friendship of those under whose care he is; and this result is not only attainable, but is almost universally achieved in

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[1] *British Medical Journal*, 1871, vol. i. p. 441.

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[1] *Lectures on Mental Diseases*, p. 217.

[2] *Ib.*

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[1] *Lectures on Mental Diseases*, p. 225.

[2] *Ib.* p. 227.

English asylums."[1] This description of the aim of treatment, valuable as it is, nevertheless shows too strongly the influence of contrast with the old system; and accordingly dwells almost unduly on the agreeable, to the neglect of the self-restraint, and therefore self-denial, which are essential to the moral life. The results enumerated are all good and agreeable, but they lean rather to the side of weakness, submission, and constant control by others. These are sought that the custodian may live in the confidence of his patient, and this is something essential for moral treatment. For it is no doubt true, as Dr. Sankey maintains, that "the public profession or avowal of the system of kindness and patience, and of the absence of all modes of punishment, and of all means of confining the patient mechanically, is of itself a *moral* remedy."[2] Kindness and patience are prominent moral qualities, and when manifested by any one in authority, are likely to encourage similar dispositions in the person who is the object of them. But to awaken these as they may be stirred in the mind of a child is not enough, since all moral treatment must aim at a self-governed life, including when needful quiet endurance of things disagreeable. This is the ultimatum to which the physician's effort is directed, and in the recognition and avowal of it, there is testimony that appliances other than medical and those of domestic regimen are to be employed. And this is testimony to the possibility of a higher life, under higher government than that afforded by nerve energy, which is upheld by suitable pabulum. This becomes clear as Dr. Sankey carries forward his discussion. He dwells upon these three features of treatment,—"Association, employment, amusement, or diversion."[3] In treating first of the patient's association with an attendant, it is well said in regulations for the latter, that "a right feeling towards the patient will usually indicate the proper conduct to be pursued." As to employment, Dr. Sankey says, "The next general moral remedy is Occupation;" it is "second in importance only to the treatment by Non-Restraint," and is "its chief helpmate still."[4] Not unnaturally it is added, with acknowledgment of the great disadvantage involved, "among the insane of the upper classes, the want of industrial employments is much felt." Continuance at employment with an intelligent regard to what is to be accomplished, is but one of the lower forms of self-regulated action, which must be established before the physician can have the satisfaction of reporting recovery. Mental occupation will promote physical improvement; and an improved physical condition will favour a freer and more inspiriting action of intelligence.

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[1] *Lectures on Mental Diseases*, p. 225.

[2] *Ib.* p. 227.

[3] *Ib.* p. 235.

[4] *Ib.* p. 240.

In entire accordance with these views, is the argument on the same subject by Dr. Maudsley. He says, "I cannot but think that future progress in the improvement of the treatment of the insane lies in the direction of lessening the sequestration, and increasing the liberty of them."[1] And still more directly, "The patient having been removed from those influences which have conspired to the production of the disease, and now tend to keep it up, and having been made to recognise from without a control which he cannot exercise from within, it remains to strive patiently and persistently by every inducement to arouse him from his self-brooding or self-exaltation, and to engage his attention in matters external—to make him step out of himself. This is best done by interesting him in some occupation, or in a variety of amusements. Steady employment will do more than anything else in promoting recovery; with the insane, as with the sane, action is the best cure for suffering. The activity of the morbid thoughts and feelings subsiding in new relations and under new impressions, more healthy feelings may be gradually awakened; and the activity of healthy thought and feeling will not fail in its turn further to favour the decay of morbid feeling."[2]

These quotations shew how decidedly those most conversant with the practical requirements for medical supervision of disease of the brain, recognise the necessity for "moral treatment," having for its aim to promote a return to self-control, and a mastery over morbid tendencies. Such testimony is the acknowledgment that personal effort is needful to secure victory over the morbid feelings which the disordered condition of the organism favours. Such references to moral considerations proclaim, that organism even though disordered is controlled by a power higher than itself.

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[1] *Physiology and Pathology of Mind*, Second Edition, p. 501.

[2] *Ib.* p. 507.

It is desirable here to refer to certain phenomena connected with moral life, which may be regarded as introducing some perplexity. I allude to the moral perversion which often occurs in the case of the insane. If a person who has led a wicked life is found to give evidence of his wickedness when placed under restraint, there is no marvel. But, under an attack of insanity, a complete reversal of conduct often occurs in the history of those who had previously led an exemplary and even noble life. It thus appears as if moral excellence depended upon the healthy condition of the brain. The evidence in proof of such "moral perversion" is abundant and beyond dispute. The interpretation of it is the matter which demands consideration. The breach of continuity which such "perversion" involves is the main feature here requiring attention. The building up of moral character is not a thing of a day. The lessons of self-restraint, endurance, and perseverance recur day by day, and are hard to learn. Through manifold struggles, at times rewarded with success, often ending in failure, progress had been made, till the man has attained to a measure of decision of character. By silent ponderings, issuing in fresh resolves, and leading out to new efforts, the lower nature is brought into subjection, while the strength, mellowness, and consistency of true moral life begin to appear. But a period of physical weakness comes, great nervous sensibility sets in, and just when strength is low, a sudden shock is encountered, under which decided disorder of brain is developed. Then it seems as if the benevolence, self-denial, and purity so much admired had evaporated, and a self-indulgent, ill-regulated life stands in melancholy contrast with the nobler conduct which was previously characteristic. Shall we say that moral character can melt away like snow before the breath of spring? Has the law of continuity so slight application in human life as to admit of a complete reversal with change of health? Or shall we say that the change in physical condition which has induced the brain disorder has imposed a physical barrier to the action of mind, and yet has left in operation all the functions of merely animal life? That the latter is the true state of the case seems evident from such an illustration as that afforded by the condition of brain which stands last in the series described (p. 462), where brain-wasting was widely extended, and the blood-vessels were hard and thick as quills. If there is continuity and not reversal in the life of the profligate, the fact is only confirmatory of the view here taken, that the animal tendencies can operate where mental government is restrained. If there is a "moral perversion" in the case of those distinguished for self-regulation when in a healthy state, the so-called "perversion," appearing in the activity of animal propensities, and the non-activity of moral forces, is in reality a testimony to the superiority of mind over matter in all the earlier history, and is not in any way an argument for the dependence of moral character on nerve energy.

III. *Violent injury to the healthy brain.*

Additional light is thrown on the relations of mind and brain by a considerable body of evidence accumulated in connection with accidental injury to the nerve centre. The head, though strongly protected by the cranium, does not escape its share of injuries, and when the skull is fractured, there is even additional risk on account of pieces of bone being driven in upon the brain tissue. In this way, serious falls, gunshot wounds, and injuries by machinery, have all contributed something to our study of brain action, under pathological conditions. A few examples, selected with some regard to diversity of phenomena, will afford illustration of the supplementary body of evidence here accumulated. In this way we can see epileptic experience and loss of self-control caused by a single instantaneous breach of the normal condition and relations of the brain. A physical injury makes palpable to the eye of the pathologist a condition which is more commonly recognised by the gradual advance of hidden disease. The locality and exact form of injury also adds considerably to the knowledge we have of the functions of different portions or lobes of the brain.

The following case, recorded by Professor Nothnagel of Jena, illustrates accidental injury resulting in epilepsy:—"A boy of eight years, who came of a perfectly healthy family, had never been seriously ill, and had had no convulsions in teething, fell a distance of twelve feet upon hard ground, striking on the head. He lay unconscious for some fifteen minutes, after which he roused, and at the end of ten minutes more was seized with a marked epileptic attack. There was a small scalp-wound on the *right* side of the head which healed in a few days. After that, for six weeks, he was in a condition of perfect health; then there was again an epileptic seizure, and from that time they have constantly recurred, in former years at considerable intervals, of late years every four to twelve days. They always occur without an aura (sensation as of a stream of air), being but very seldom preceded by a momentary dizziness. *They invariably begin by a turning of the head to the left*; consciousness is then first lost, the countenance becoming pale at the same time, and general convulsions declare themselves. Interparoxysmal symptoms exist to a limited degree; from time to time only a little headache; and sometimes there appear slight twitchings in the *left* half of the face or in the *left* arm. The patient, who is now a vigorous person of twenty-one years, appears to be of rather limited mental powers, and complains of a weak *memory*. Objectively there is nothing to be discovered except a cicatrix, about the size of a lentil, corresponding to the *right* coronal suture, and four centimetres distant from the medial line. This is not painful or adherent, and when touched, either gently or quite roughly, no symptoms are manifested, no epileptogenous zone is to be found."[1] Under such conditions as those described, it is certain that there must be lifelong restraint upon the action of mind, if we judge of its action by the power of concentrated attention. And when it is said that the patient "complains of weakness of memory," this harmonises with what has been already shown as to the large degree in which memory depends on brain action.

In view of the importance commonly assigned to the anterior lobes of the brain, special interest naturally concentrates on injuries to the frontal regions. On this account it is desirable to select illustrations bearing to some extent on the functions of this portion of the nerve centre.

In connection with his investigations as to the centre for speech, Dr. Bateman has transcribed a case of interest in this relation. "In Trousseau's *Clinique Médicale* the following case is recorded :—In the year 1825, two officers quartered at Tours quarrelled, and satisfied their honour by a duel, as a result of which one of them received a ball which entered at one temple, and made its exit at the other. The patient survived six months without any sign of paralysis or of lesion of articulation, nor was there the least hesitation in the expression of his thoughts, till the supervention of inflammation of the central substance, which occurred shortly before his death, when it was ascertained that the ball had traversed *the two frontal lobes at their centre.*"[1] The two negative results, absence of paralysis, and non-disturbance in the expression of thought, are of undoubted importance in the interpretation of brain functions.

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[1] Ziemssen's *Cyclopædia of the Practice of Medicine* (transl.), vol. xiv. p. 208.

The most striking case in this relation is that which is now widely known as "the American Crowbar Case." The facts were first described by Dr. Bigelow,[2] and the subsequent history of the sufferer was detailed by Dr. Harlow, in a paper read before the Massachusetts Medical Society, June 3, 1868. Dr. Ferrier has given considerable attention to the case, presenting a drawing of the skull as it is now preserved in the Medical Museum of Harvard University, Massachusetts, and from him I take the account of the case, along with his critical remarks on the mental activity of the man subsequent to the accident.

"The subject of the lesion was a young man, Phineas P. Gage, aged twenty-five. While he was engaged tamping a blasting charge in a rock with a pointed iron bar, 3 feet 7 inches in length, 1¼ inches in diameter, and weighing 13¼ lbs., the charge suddenly exploded. The iron bar, propelled with its pointed end first, entered at the left angle of the patient's jaw, and passed clean through the top of his head, near the sagittal suture in the frontal region, and was picked up at some distance covered with 'blood and brains.' The patient was for a moment stunned, but, within an hour after the accident, he was able to walk up a long flight of stairs and give the surgeon an intelligible account of the injury he had sustained. His life was naturally for a long time despaired of; but he ultimately recovered, and lived twelve and a half years afterwards. Unfortunately, he died (of epileptic convulsions) at a distance from medical supervision, and no *post-mortem* examination of the brain was made; but, through the exertions of Dr. Harlow, the skull was exhumed and preserved. Upon this the exact seat of the lesion can be determined. The line of union of the cicatrices of entrance and exit, however, allowed a pretty accurate estimation of the track of the bar during life, and Dr. Bigelow did so with considerable accuracy. Dr. Bigelow, who examined the man two years after the accident, thus describes the appearances presented:—'A linear cicatrix of an inch in length occupies the left ramus of the jaw near its angle. . . . The eyelid of this side is shut, and the patient unable to open it; the eye considerably more prominent than the other. [Vision lost (Harlow).] . . . Upon the head, and covered by the hair, is a large unequal depression and elevation. . . . A piece of the cranium of about the size of the palm of the hand, its posterior border lying near the coronal suture, its anterior edge low on the forehead, was raised upon the latter as a hinge, to allow the egress of the bar; still remains raised and prominent.

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[1] Bateman's *Aphasia*, p. 19.

[2] *American Journal for Medical Sciences*, July 1850.

"From his examination of the skull itself, Dr. Harlow thus describes the track of the bar:—'The missile entered, as previously stated, immediately anterior and external to the angle of the inferior maxillary bone, proceeding obliquely upwards in the line of its axis, passed under the junction of the superior maxillary and malar bones, comminuting the posterior wall of the antrum, entered the base of the skull at a point the centre of which is an inch and a quarter to the left of the median line, in the junction of the lesser wing of the sphenoid with the orbitar process of the frontal bone—comminuting and removing the entire lesser wing with one half of the greater wing of the sphenoid bone—also fracturing and carrying away a large portion of the orbitar process of the frontal bone, leaving an opening in the base of the cranium, after the natural efforts at repair by the deposit of new bone, of one inch in its lateral, by two inches in its antero-posterior, diameters.' (*Op. cit.* p. 17.)

Dr. Harlow does not describe the further track of the bar through the frontal bone, but you will clearly see, from the figures, that the whole lesion is situated anterior to the coronal suture. If, now, you will compare the track of the bar through the skull and brain with the diagram before you (fig. 3) showing the relations between the skull and the brain, you will, I think, have no doubt in convincing yourselves that the whole track is included within that region of the brain which I have described as the præ-frontal region, and that, therefore, the absence of paralysis in this case is quite in harmony with the results of experimental physiology. The only other region which the bar could have injured is the tip of the temporo-sphenoidal lobe and the outer roof of the olfactory bulb. Respecting the condition as to smell, nothing is, however, said by either Bigelow or Harlow. This case is generally quoted as one in which the man suffered no damage bodily or mental. But hear what Dr. Harlow says as to his mental condition. 'His contractors, who regarded him as the most efficient and capable foreman in their employ previous to his injury, considered the change in his mind so marked that they could not give him his place again. The equilibrium or balance, so to speak, between his intellectual faculties and animal propensities seems to have been destroyed. He is fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires, at times pertinaciously obstinate, yet capricious and vacillating, devising many plans of future operation, which are no sooner arranged than they are abandoned in turn for others appearing more feasible. A child in his intellectual capacity and manifestations, he has the animal passions of a strong man. Previous to his injury, though untrained in the schools, he possessed a well balanced mind, and was looked upon by those who knew him as a shrewd, smart business man, very energetic and persistent in executing all his plans of operation. In this regard his mind was radically changed, so decidedly, that his friends and acquaintances said he was "no longer Gage."' (*Op. cit.* p. 18.)

"After these facts, I do not think it can be said with justice that the man suffered no damage either bodily or mentally, or that the 'American Crowbar Case' is in opposition to the experimental facts which I have adduced as to the effect of lesions of the frontal lobes."[1]

The most important facts in the experience of Gage bearing directly on the present inquiry are these;—that an hour after the accident he was able to give an intelligible account of the injury he had sustained; that he showed in after-life want of self-control; that this appeared in a predominance of animal propensities, fitfulness as to personal purpose, impatience, excitability, and stubbornness when interfered with; but there was no failure in power to hold intelligent communication with others. The whole account indicates want of governing power; but it does not show such interference with intelligent action as to make the man incapable of appreciating distinctions, or accurately describing events. His companions rightly estimated the situation when they said he was "no longer Gage," meaning that he was no longer capable of attempting the work he could once do, or of directing others as he had done before. But the whole bearing of the case is misunderstood if the testimony of his possessing "a well-balanced mind" before the accident, is interpreted as meaning anything more than well-directed effort in the performance of the work of a quarryman. He was not a man of even average education, much less of any intellectual power. The failure in self-government which appeared might, indeed, readily enough be described as "moral perversion," and yet it would be most erroneously described under such a designation. If anything be obvious it is this,—that as Gage was not responsible for the accident which befell him, so neither was he responsible for the difficulty in controlling himself which he experienced. But it does not therefore follow that it was not his duty to begin an entirely new effort at self-control, required in his altered circumstances. His greater difficulties entitled him to greater consideration, but did not terminate his obligations. It is obvious that the man had a continual sense of uneasiness; that he had a painful consciousness of inability to work as he had done; that he was "impatient of restraint or advice when it conflicted with his own desires," such "restraint or advice" involving an addition to the burden of "restraint" which already tried his spirit. These two last-named facts imply a mind disturbed, yet dealing with the difficulties of his painful situation. His impatience of restraint and advice are to be accounted for partly by uneasiness, partly by an intelligent effort to regulate physical action under the distraction which the uneasiness occasioned. His impatience discovers more than physical uneasiness. He was impatient of advice. This was clearly the irritation of a reflective nature, disturbed by the uneasiness of the physical nature, and aggravated by counsels which do not help, but hinder the mind in its endeavours. There is no possibility of making an intelligible harmony of the narrative except on this clear admission. The speciality of the case is the illustration it affords of a person contending throughout thirteen years with extraordinary disturbance of functional activity in the nerve centre, and continuing to show accurate intelligence, along with inadequate power of control. How serious the physical disturbance had been, became apparent at length in the fact that the sufferer "died of epileptic convulsions." The result of his physical state must have been irritability, liable to be excited by conflicting advice. Dr. Ferrier has said, "I might multiply instances all demonstrating the same fact, that sudden and extensive lacerations may be made in the præ-frontal region, and large portions of the brain-substance may be lost, without causing impairment either of sensation or of motion; and, indeed, without very evident disturbance of any kind, bodily or mental, especially if the lesion be unilateral."[1] These words may require some modification if applied to the experience of Gage; but the case affords a striking illustration of Dr. Ferrier's statement. Additional importance attaches to its bearing on the functions of the frontal lobes, with which the intellectual and governing powers of human life are commonly associated. A breach of the controlling power resulted from the injury to the frontal region; but there is evidence of comparatively little inroad on the intelligence proper. In this connection it is desirable also to keep in view the fact that the activity of the intellectual powers has been associated with the *posterior region* in the brain. On this point Dr. Bastian presents his testimony in the following form:—"Various reasons led me some years ago to the conclusion that the posterior lobes of the brain had more to do with higher intellectual functions than the anterior lobes—a conclusion which, however contrary it may be to generally received opinions, has since been strengthened by observations made independently in different directions and by different persons. It seems to agree, moreover, with clinical and pathological evidence. Dr. Hughlings Jackson and other authorities on the subject of brain disease agree with me in thinking that mental impairment or derangement is apt to be more especially marked where we have to do with injuries of the posterior lobe of the brain—that is, such signs are prone to be more marked than with lesions of the anterior lobe of the brain, notwithstanding the popular notion as to the decidedly greater importance of this part in respect to intellectual functions."[1] In so far as one may judge from premonitory symptoms resulting from overwork, I can testify from repeated experience that uneasiness is first experienced in the frontal region; at a stage in advance of this, an uneasy feeling sweeps at times over the upper region from front to rear; and at a third stage, this is followed by a stroke or sudden shock in the posterior region. Whether this implies that superior activity belongs to the posterior lobes, or that the organ acts in some sense as a whole, while the governing power belongs to the frontal region, I should not venture to conclude.

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[1] *Localisation of Cerebral Disease*, pp. 28-30.

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[1] *Localisation of Cerebral Disease*, p. 33.

There is still another possibility, as the result of accidental injury, which deserves passing attention,—I mean the loss of a portion of brain substance not only without detriment, but with perceptible advantage to the performance of brain functions. Examples of this must be of rare occurrence, as are examples of microcephaly. The relation of the mass of brain to the cavity of the skull in which it is stored is so suitable, that there is in the normal condition an exact adaptation. In the history of disease, however, such facts as these are familiar, that the formation of a tumour on the brain, and consequent pressure on a portion of the substance of the brain, may interrupt functional activity of the underlying part, and also that accumulation of fluid may not only greatly distend the cranium, but impede the action of the cerebrum. Apart from such forms of disease, however, there may be cases of megalocephaly, in contrast with those of microcephaly. It is possible that brain development may so far exceed the natural capacity of the cranium, as to cause the grey matter to press considerably against the hard walls of the cavity, inducing compression of the organ as a whole. Dr. James Sidey of Edinburgh, the surgeon who attended the patient, has favoured me with the particulars of a case which deserves to be recorded:—"A naavy, while working at the formation of the Leeds and Thirsk Railway, was struck by a revolving crane handle on the upper part of the left parietal bone, producing a compound comminuted fracture, with (*hernia cerebri*) protrusion of the brain as large as a bantam's egg. After admission to the Hospital, the case did well, about ten or twelve small pieces of bone were removed—the protruding brain sloughed off, the wound healed over, and the man was discharged about six weeks after admission, without having shown any bad symptoms or taken one single dose of medicine during his stay there. Previous to admission he was misanthropic, lived in a hut alone, washed his own clothes, cooked his own food, and seemed peculiar in many ways. A month after he was dismissed from Hospital he married, and ever afterwards conducted himself as a most respectable member of society, showing none of his former peculiarities." This case may be regarded as in some respects a companion with the "American Crowbar Case." But the improvement on the sufferer is a speciality. Mental activity being an exercise in many respects superior to brain action, his appreciation of kindly nursing may have had a good deal to do with the cure of misanthropy, as well as the cure of the broken head. But the fact deserves notice, that improvement in disposition and conduct followed upon a loss of brain, which does not seem to have been in any degree detrimental.

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[1] *Paralysis from Brain Disease*, p. 239.

In closing these investigations as to brain disorder, it is desirable briefly to consider the relation of personal power to the tendencies which induce insanity, and to those influences which avert the action of such tendencies.

1. *Personal conduct may induce insanity.*

Apart altogether from questions of heredity, it is clear that certain courses of action tend to induce insanity. The laws of health apply as rigidly for brain as for lungs, heart, and liver. We have seen that immorality, whether in the form of drunkenness or licentiousness, predisposes to insanity. At the other extreme, overwork of brain, taxing its energy by the number of hours devoted to study or mental work of other kinds, may induce exhaustion and active disease, thereby hindering the ordinary exercise of self-control. Just as truly as the lower and most debasing forms of immorality are to be shunned, so are also the excessive efforts of industry and concentrated thought, which, by their breach of the laws of health, involve in their own way a phase of immorality. There are symptoms which warn us clearly enough of overworking of brain, and which we are under obligation to treat as warnings of danger. Personal purpose may exact more than the physical organ can endure, an obvious token of the superiority of mind to brain. On the other hand, personal observation may mark the symptoms of danger, and personal determination may avert the consequences which would otherwise follow,—another fact which contributes its complement of evidence to the superintendency which the intelligence wields over brain. An additional form in which, as previously remarked, we are exposed to danger is that arising from the sudden shocks to which our life is liable. Sudden and great calamity,—or a succession of disasters of any kind coming rapidly in personal history,—involves a risk, greater or less, according partly to the condition of health in which the trial finds us, and partly to the degree in which we have trained ourselves to endure suffering and sorrow. The hazard from such calamities is in some sense greater, because we cannot guard against their occurrence, and cannot take measures to secure that when they do break upon us, it shall not be when we are in an enfeebled condition. In personal and domestic history, such trial must often find us in a physical condition ill prepared for endurance. Our single defence in such circumstances is that which is supplied by a sound moral training in the needful work of endurance, directed by true views of the secondary value of material possessions, of the superior value of human nature, and the grandeur of its destiny, in harmony with the government of an absolute Moral Ruler of the universe.

Apart from such natural calamities as those to which all are liable, it must be added that special risks attend upon the continuance and encouragement of abnormal excitement of brain. The life of De Quincey is full of instruction in this respect.[1] Under the same category come all cases in which an unnatural excitement is kept up during sleep, whether that be natural slumber, or artificially induced, as in the case of "mesmeric sleep." Among the cases preserved for us by Dr. Abercrombie, there is one which deserves special notice as illustrating what is here under consideration:—"A girl aged seven years, an orphan of the lowest rank, residing in the house of a farmer, by whom she was employed in tending cattle, was accustomed to sleep in an apartment separated by a very thin partition from one which was frequently occupied by an itinerant fiddler. This person was a musician of very considerable skill, and often spent a part of the night in performing pieces of a refined description; but his performance was not taken notice of by the child except as a disagreeable noise. After a residence of six months in this family she fell into bad health, and was removed to the house of a benevolent lady, where, on her recovery after a protracted illness, she was employed as a servant. Some years after she came to reside with this lady, the most beautiful music was often heard in the house during the night, which excited no small interest and wonder in the family; and many a waking hour was spent in endeavours to discover the invisible minstrel. At length the sound was traced to the sleeping-room of the girl, who was found fast asleep, but uttering from her lips a sound exactly resembling the sweetest tones of a small violin. On further observation it was found that, after being about two hours in bed, she became restless and began to mutter to herself; she then uttered sounds precisely resembling the tuning of a violin, and at length, after some prelude, dashed off into elaborate pieces of music, which she performed in a clear and accurate manner, and with a sound exactly resembling the most delicate modulations of that instrument. During the performance she sometimes stopped, made the sound of retuning her instrument, and then began exactly where she had stopped, in the most correct manner. These paroxysms occurred at irregular intervals, varying from one to fourteen or even twenty nights; and they were generally followed by a degree of fever, and pains over various parts of her body.

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[1] *Confessions of an Opium Eater.*

"After a year or two, her music was not confined to the imitation of the violin, but was often exchanged for that of a piano of a very old description which she was accustomed to hear in the house where she now lived; and she then also began to sing, imitating exactly the voices of several ladies of the family. In another year from this time she began to talk a great deal in her sleep, in which she seemed to fancy herself instructing a younger companion. She often descanted with the utmost fluency and correctness on a variety of topics, both political and religious, the news of the day, the historical parts of Scripture, public characters, and particularly the characters of members of the family and their visitors. In these discussions she showed the most wonderful discrimination, often combined with sarcasm, and astonishing powers of mimicry. Her language through the whole was fluent and correct, and her illustrations often forcible, and even eloquent. She was fond of illustrating her subjects by what she called a *fable*, and in these her imagery was both appropriate and elegant. 'She was by no means,' says my informer, 'limited in her range—Buonaparte, Wellington, Blücher, and all the kings of the earth, figured among the phantasmagoria of her brain; and all were animadverted upon with such freedom from restraint, as often made me think poor Nancy had been transported into Madame de Genlis' Palace of Truth. The justness and truth of her remarks on all subjects excited the utmost astonishment in those who were acquainted with her limited means of acquiring information.' She has been known to conjugate correctly Latin verbs which she had probably heard in the school-room of the family; and she was once heard to speak several sentences very correctly in French—at the same time stating that she heard them from a foreign gentleman whom she had met accidentally in a shop. Being questioned on this subject when awake, she remembered having seen the gentleman, but could not repeat a word of what he said. During her paroxysms it was almost impossible to awake her, and when her eye-lids were raised, and a candle brought near the eye, the pupil seemed insensible to the light. For several years she was, during the paroxysms, entirely unconscious of the presence of other persons; but, about the age of sixteen, she began to observe those who were in the apartment, and she could tell correctly their numbers, though the utmost care was taken to have the room darkened. She now also became capable of answering questions that were put to her, and of noticing remarks made in her presence; and, with regard to both, she showed astonishing acuteness. Her observations indeed were often of such a nature, and corresponded so accurately with characters and events, that, by the country people, she was believed to be endowed with supernatural powers.

"During the whole period of this remarkable affection, which seems to have gone on for at least ten or eleven years, she was, when awake, a dull, awkward girl, very slow in receiving any kind of instruction, though much care was bestowed upon her; and, in point of intellect, she was much inferior to the other servants of the family. In particular she showed no kind of turn for music. She did not appear to have any recollection of what passed during her sleep; but, during her nocturnal rambling, she was more than once heard to lament her infirmity of speaking in her sleep, adding how fortunate it was that she did not sleep among the other servants, as they teased her enough about it as it was. About the age of twenty-one she became immoral in her conduct, and was dismissed from the family. Her propensity to talk in her sleep continued to the time of her dismissal, but a great change had taken place in her nocturnal conversation. It had gradually lost its acuteness and brilliancy, and latterly became the mere babblings of a vulgar mind, often mingled with insolent remarks against her superiors, and the most profane scoffing at morality and religion. It is believed that she afterwards became insane."[1]

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[1] Abercrombie's *Intellectual Powers*, 12th edition, pp. 245-248.

This case illustrates in a singular way how brain excitement may be induced, and how by persistent subjection to such excitement during the hours of sleep, a physical condition is brought about which tends towards insanity. The significance of the facts may be seen if we note the successive stages in the history of the case. The girl was only *seven* years of age when disturbed by the playing of the violin. Her sleep was not broken by this, but her brain was kept in an excited condition, and that at a period in life when such excitement is apt to have a most disturbing and persistent effect (p. 437). She was a girl who had no educational advantages, and few of the attentions which the home circle supplies;—"an orphan of the lowest rank," tending cattle, and apparently having her sleeping quarters in a barn or hay-loft, for that has been the common place in the farm houses of Scotland for spreading a bed for wandering minstrels. After six months she passed through a severe illness in which brain excitability is likely to have been increased. In the new and more favourable sphere of service to which she was transferred, the sensitiveness to sounds was acted upon afresh by musical performances strange to her. There it was discovered that about two hours after she had gone to bed,—probably the time about which the itinerant violinist began to tune his instrument,—"she became restless." Then she "began to mutter to herself." This appears to have been a repetition of the natural complaint she made on account of disturbance of sleep. Next, she began her imitations of the music she had heard. This was the reflex action of the brain, reproducing the cause of excitement, and thereby intensifying (p. 55) the excitability. The physical result of disturbed sleep and excited brain was "a degree of fever, and pains over various parts of her body," the fever being a natural consequence, and the pains being probably induced by muscular activity connected with the imitation of actions quite unusual to her. Next came evidence of having experienced extended impressions from musical effects, leading to imitations of the piano. Thus an abnormal excitability to the influence of sound was being established. And nothing was done to break the tendency. Unfortunately everything seems to have been done to stimulate it. The performances of the girl became matter of curiosity. People gathered together in her sleeping chamber to listen and to watch,—not to break the spell, and set the poor child free, —their whisperings and merriment added to the unnatural excitement of the nerve system, and tended to aggravate it. Then at length—*nine years* after the first manifestation of restlessness in sleep—her attention was called into activity to interpret what was spoken to her, and reply to her questioners. Sensitiveness of brain was thus acted upon in new ways. Singular sounds, such as the words of a foreign language, or explanations of things not understood, produced a vivid impression on a brain excitable to an unnatural degree. To the musical performances of the night were now added recitations, conjugations of verbs, and repetitions of historical narrative. A more effectual means of utterly ruining a nerve system could hardly be devised, and as a certain result the power of personal control was being sacrificed. Nothing seems to have been done to direct her own attention on the malady to which she was subject, or to encourage her in an effort to break the spell and end the dominion which had become established. There was teasing enough by day, as well as brain excitement by night; but a want of requisite help to break the pernicious habit. If only an effort had been made in the direction which Dr. Thomas Reid describes (p. 425) as having been successfully made in his own case at the age of fourteen, she might have been saved from life-long injury. "About the age of twenty-one she became immoral." The animal nature, excited and ungoverned, was under no control of the intelligent nature, and the history of her domestic service is ended by saying, that she was "dismissed from the family;" the life record is closed by saying—"It is believed she afterwards became insane." There is little demand upon belief in such a case; she was insane before she was dismissed, and this "immorality" was after the type of "moral perversion" found among the insane, and which with no show of reason can be described as "immorality," but only as "insanity,"—a disordered brain and an excited physical condition.

The case affords a striking illustration both of the power and the weakness of brain. A summary of its contribution to the evidence concerning the relations of mind and brain is desirable. We have a series of abnormal manifestations of brain activity consequent on disturbed sleep, inducing chronic excitement of the organ. This excitement is connected with the condition of sleep, and does not appear when the patient is awake. During the paroxysm the condition of brain differs so much from that of ordinary sleep, that it is "almost impossible to awake her." There are here two distinct orders of facts, the one bearing on the abnormal activity of brain, the other on ordinary mental activity during the abnormal excitement. (1.) *There is imitation, without intelligent appreciation.* There is wonderful musical imitation—a singular example of brain activity operating upon the vocal organs in a way which could not be easily executed by an accomplished musician in his waking hours. Indeed we may say that the more accomplished the musician the more difficult would prove the attempt to reproduce the effects produced with facility by this illiterate girl during the paroxysm of brain excitement. Her imitation is mechanical, and this so completely that she imitates the "tuning" of the violin, and even stops for "retuning," as no person attempting vocal imitation of the violin would dream of doing. In accordance with the purely mechanical nature of the action during a period of abnormal brain excitement, the girl never thought of attempting the exercise during her waking hours. Thought played no part in the production of the effects. (2.) *There is some intelligent action accompanying the paroxysm, and quite distinct from it.* She occasionally is heard to speak, and when she does so, it is to "lament her infirmity of speaking in her sleep," adding a reflection by way of comfort to herself, "how fortunate it was she did not sleep among the other servants, as they teased her enough about it as it was." The mind carried a burden of sorrow on account of the abnormal condition of brain which had been induced. At an advanced stage in the history of the case mental activity is brought into co-operation with the brain excitement. By an appeal to her through the organ of hearing, she is led to take account of the presence of others, and to answer their questions. This involved a serious addition to the already dangerous excitement of brain, and a disastrous end became certain. When out of the paroxysmal excitement there was no manifestation of intellectual power. She showed no power of musical effort when it depended on voluntary imitation. She had no recollection of her musical performances during sleep. She was slow in receiving instruction, and had no educational advantages fitted to develop the intelligent nature. In strict harmony with this, it is recorded that when the brain injury was becoming apparent, her utterances in sleep were "the babblings of a vulgar mind."

2. *Intelligent self control may avert insanity.*

After the lengthened consideration of the manner in which insanity may be induced, I shall not devote large space to the power which may be wielded for maintaining self-government when subjected to disturbing brain affections. If a person contemplate abnormal experience in its true light, if he distinguish between personal activity and induced malady, if he have previously acquired habits of self-government, and bring them into use under intelligent recognition of the facts of the case, he can be his own physician in a most effective way. He will value the co-operation of friends and the counsel of the experienced physician; but chiefly will he deal with the situation as imposing upon himself a special duty, cessation from the brain work, or separation from the disturbing influence which induces excitement; and he will resort to muscular activity, open-air exercise, variety of scene, variety of interest; in short, every kind of occupation which favours a healthy physical condition, with temporary abandonment of mental effort. I speak of this as duty; it is the one pressing demand of moral life for the time being. This single consideration has determining value for all treatment of brain disorder. In sight of it Dr. Maudsley has properly raised the question, "How far is a man responsible for going mad?" To this he replies—"This is a question which has not been much considered, yet it is one well worthy of deep consideration; for it is certain that a man has, or might have, some power over himself to prevent insanity. However it be brought about, it is the dethronement of will, the loss of the power of co-ordinating the ideas and feelings; and in the wise development of the control of the will over the thoughts and feelings, there is a power in ourselves which makes strongly for sanity."[1] Such "wise development of the control of the will" as is here commended, belongs to the normal life of man, whether he be educated or uneducated; but in saying this, it is granted that there is a personal control superior to brain action, and which may keep ascendency in midst of the disturbing experiences of a disordered brain. This declaration, confirmed as it is by a large body of evidence, and brought into application by the physician in his treatment of sufferers, affords definite and very express testimony to the superiority of mind over brain.

Responsibility in Mental Disease, p. 268.

CHAPTER XV.

THE HIGHER FORMS OF MENTAL ACTIVITY.

In order to complete the present inquiry, there still remain for consideration all the higher departments of intellectual activity familiar to man. Hitherto we have dealt with mental action, as it is closely related with bodily activity. Now we pass up into a higher region, where mind is at the maximum of activity, body at the minimum. Here we leave behind us the use of the senses, having already ascertained the conditions regulating their activity, and what is the kind of knowledge they afford. Now we come to inquire how that knowledge is arranged, classified, and put to higher use, and how mind rises to problems and ranges of thought higher than any included within the area of the sensory. Here also we pass from all that is concerned with the management of the muscular system and mere bodily activity, including activity of motor nerves and our use of muscular power. Now we must consider what higher forms of human thought and activity there are concerned with the acquisition of scientific knowledge and the guidance of life as a whole. Here we come in sight of the higher reaches attainable by man as a thinker, as these stand clearly in view of men generally, so that the sight of them has influenced the whole history of our race, even though they have been explored by only a few, as adventurous travellers attempt the Alpine heights. In the higher forms of mental activity concerned with the guidance of conduct, or with scientific questions, or with more abstract and speculative problems, we find the distinguishing characteristics of human life. So long as we are dealing with comparative anatomy and physiology, we are contemplating man's participation in animal life, and affinities with the animals. Even when we study the comparative intelligence manifested in animal life, we rise to a level only a little higher, where we find ourselves separated from lower orders of animal existence, but still closely allied with higher orders, which may thus far be recognised as the companions of man in his activities. But when we come to contemplate man purely as a thinker, and consider the vast work which has been achieved by him, of which literature, poetry, art, science, and philosophy, present the evidences, we recognise man apart from all other orders of being in the universe. Here there is no companionship of animal life. Man moves alone on a higher altitude, and works unaided by lower forms of life which render service in subordinate work. We discover and discriminate the specific characteristics of human life, peculiar but common to the race, at the same time marking the higher achievements of some, and forecasting the possibilities of progression for each individual and for the race as a whole. Here, for the first time in the whole course of the present inquiry, we reach the vantage-ground whence we can see the true place of man in the scale of being. By looking from this position downwards upon lower orders of being to which the present height is inaccessible, we see, as we could not from a lower point of observation, how far man's position is above that occupied by the most highly endowed animals.

We are now, then, to contemplate man as a thinker. In doing so, it becomes needful to distinguish certain departments of thought; the intellectual, or that which is concerned with the understanding of things; the moral, or that which takes cognisance of the regulation of a higher life, in accordance with a higher type of law known to a rational being; and the religious, which has regard to man's relation to an invisible order of things, and to an Absolute Being, as the source and governor of all things finite, equally the visible and the invisible. In all these departments the specific characteristics of human thought are apparent, as they are common to all the three. We find ourselves amongst the generalisations, the conceptions, the inductive and deductive processes,—indeed, the whole work essential to synthesis of knowledge. The laws which regulate the higher forms of mental activity are the same in all the three departments. There is no distinction to be drawn between them in this respect. Yet are they so different as departments of thought, that some minds concern themselves far more with one of the departments than with the others. Some show an intellectual interest concentrated chiefly on the understanding of things as existing in the material universe, and the most qualified among such thinkers aim at contributing their share to the advance of science. Some who have little familiarity with these regions of research, bestow much thought on the requirements of self-discipline, the management of life as a whole, and the attainment of an excellence towards which approximation may be made, even while bodily strength is failing. Others enlarge this range of thought by considering the relation of practical life to a system of things greater than the visible—seeing the invisible and eternal—and finding a harmony of existence in the absolute excellence of the Deity. In this department also we find a phase of higher mental activity concerned more with the intellectual problems which urge the human mind into fields of speculation, than with the requirements of a moral and religious life. From these few statements it is apparent that there are three departments of higher thought which are capable of being regarded as rigidly distinct, while they afford common tests of the power of human intelligence. If this last consideration be kept in view, it will be seen that we have a common field of testimony before us, even while we distinguish three departments of inquiry. Though some show an aptness for only one of these regions of thought, and special interest in it, all have some share in the thought which belongs to the three. There is no mind which does not experience an influence from the scientific, the moral, and the religious, or at least the speculative thought of the race. We have a unity in the wide range of thought which includes the three departments, and evidence for the unity of our race in the fact that, in greater or less degree, there is universal experience of the power of such thought. The least scientific have some appreciation of the advance which science makes, as appears from the difference of thought amongst the slightly educated, in contrast with the thought of the same class when science was in its infancy. There is a gradual deliverance from superstitions as the result of some intelligent application of the conclusions of science. On the other hand, and at the other extreme, the enthusiastic disciples of science find it impossible to restrict themselves to science. In vain has it been proclaimed that we should cease from the search for causes, and restrict ourselves to the study of facts. The speculative tendency of the human intellect is too strong to be restrained by such barriers. There is an "ought" before which human intelligence will bow, and that the more readily and reverently the longer it thinks of its claims; but that man should not think of things beyond the range of his own experience is an "ought" which man as a thinker will not recognise, and the more fully its import is understood, the more certain it becomes that the suggestion will be banished as a scandal to the race. While we as individual thinkers occupy our little place in the expanse of time, there is for us thought concerning the past and the future—concerning the origin of existence of which we form a part, and the continuity of existence—which is the natural fruit of intellectual action on the facts of existence. And so it has happened, after an ineffectual barrier was raised to debar science from the search for causes, that physical science has pressed forward to a metaphysical region, and has intensified the interest of the whole civilised world in the two questions concerning the origin of existence and its destiny. Such facts as these show how important for us is the inquiry, What is man, regarded simply as a thinker? Towards an answer we must investigate the three departments of thought into which we have seen the higher forms of mental activity may be divided.

1. *The purely intellectual department of thought.*

Within this division falls to be included all thought concerned only with the understanding of things as existing. This must embrace the entire range of such thought, from that of the child who is concerned with the "how?" and the "why?" up through all the varieties of thought belonging to the practical man, until we have reached science proper, the systematised and rationalised order of things. Our problem is this,—Can such ranges of thought be regarded as functions of nerve tissue, and explained under the laws of nerve action? To answer this problem in the affirmative is the task which those have assigned to themselves who urge that thought is a function of brain. The task does not seem a very easy one, nor does there appear great eagerness to undertake responsibility for a completed demonstration.

A general outline of the range and conditions of this region of thought will show the nature of the problem as concerned with brain and mind, and the ground on which it appears that brain is unequal to such work. Here we must recall the results of previous inquiry as to lower forms of mental activity. We have seen that perception of external objects, as it belongs to human experience, implies in its ordinary exercise comparison and memory. That is to say, to observe objects as we do when we say coal, iron, stone, and wood, is not merely to see certain things, but to compare, and to draw upon the results of past observations. We have further ascertained that management of motor activity, as it is known to us, implies reflection and will. That is to say, we are well aware that we consider within ourselves what it is best to do in given circumstances, and after we have seen the course of action clearly, we determine upon it, and the whole motor activity which results is the product of our own determination, though it could not have been accomplished without nerve energy and muscular power. From examination of these lower orders of activity we have found that comparison,—recollection of the results of past comparisons,—inference, and volition, are all characteristic of man, and cannot be accounted for under the laws of nerve energy. This being true, still less can the higher powers of intellectual activity be so explained, and the more obvious does it become that mind is a superior order of existence, performing work unapproachable under the laws of nerve action.

Advancing beyond the intelligent perceptions which constitute the early exercises of childhood, the mind reaches generalised truth, and forms representative conceptions of things. These forms of activity do not depend upon a full development of brain (see p. 13); they are carried on early in life. At quite an early period the child is working with generalised truths, representative conceptions and abstract terms. The circumstances of the child as resident in the city or in the country have much to do with his mental activity; his food, and rest, and health of brain are necessary conditions for observing things around, and thinking of what he sees; but all these are insufficient to account for the fact that from day to day he is discovering more than he sees. The sensory and motor systems of nerves, with the several adjustments of cellular tissue belonging to the nerve centre, will account for his observations, and the amount of muscular activity he puts forth under the interest which these observations awaken. But the discriminating and classifying processes by which he gathers a store of general knowledge concerning birds and fishes, and the forces operating in the material world, cannot be so explained. Brain power will account for what is common in the observations and wanderings of childhood's years. Superiority or inferiority of brain power may afford the key to diversity in quickness of observation, and in power of endurance, or readier sense of weariness, during the rambles of a summer's day. Superiority of brain action may explain the vividness of recollection with which some recount the incidents of the day, in contrast with what seems to be the comparative forgetfulness of others. But when the children are silent and still, when they are reflecting over things which have awakened their curiosity, and when they come to their seniors seeking help towards explaining how certain things happen, or why things are arranged in a particular way, they are engaged with forms of activity which are not accounted for by the laws of brain action. It is not, indeed, to be thought possible that an explanation of these forms of activity can be given irrespective of brain; but, after we have assigned to brain all that the most advanced research warrants, we cannot complete a theory of the facts. I refer for illustration here to the period of childhood, because this is an essential part of our problem, that such phases of intellectual activity as those described are not the special occupations of mature years, but are possible to man at a very early period of life. A human intellect with stores of generalisations, representative conceptions, and inferences, has a history long before the period when maturity of brain is reached. Accordingly, even a child is scientific in the nature and form of his thought. He teaches himself by what he observes, and is not merely taught by others; and in this process the laws of rational procedure are quite distinct from those of brain action. How different all this is from the spontaneous action of the chick, described at an earlier stage of inquiry, must be apparent.

Here then we reach the essential characteristic of human life, as it appears at an early stage in efforts which are first steps towards the higher walks of science reached only by a higher concentration, and a more persistent use of the intellectual powers which are at the command of all, and more or less exercised by all.

Along the line of the advancing degrees of intellectual activity, we reach a better appreciation of the essential features of human personality; and here by consequence we come more distinctly on the contrast between quality of brain and range of intellectual attainment. The history of scientific thought in itself affords a good test of the relation of intellectual progress to brain power. There has been within less than a century an immense advance in physical science. But, it is not maintained that there has been within this period some new and astounding development of brain power. It is not suggested that we have seen the evolution of a more complex type of organism than existed in the seventeenth or the eighteenth century. The microscope has multiplied our powers of observation, and quite changed our modes of teaching science; and our literature has placed within easy reach of the reader what could not formerly have been gathered as the reward of half a lifetime of study. These are the explanations of the difference.

There was, under the old methods, the same demand upon observation for reaching the results then attained, although the appliances at command were fewer. And, indeed, the scantier provision of instruments afforded, in some measure, a greater test of the intellectual work done. If, therefore, we make account of the progress of scientific knowledge, we see that prior thought prepared the way for the minuter observations of the present day; and if the full significance of recent advances is to be ascertained, it can be only by continued exercise of the thought which did so much before microscopic investigation began. And this is work which does not find its explanation in the laws of brain activity. It is not merely difference of brain development which explains the difference between a man of ordinary education, a man who is a scientific observer, and a man who works even more in a region of thought than of observation. When we contrast brain work and the higher efforts of thought, the words of Sir Charles Bell may fitly guide us by recalling the fact that much of brain work is common to man. He says, "It is taken for granted that we who exercise our best faculties within the four walls of a house, must have a development of brain beyond what the free-dweller in the plains or forests of what is termed a new country can possess. I believe, on the contrary, that man in his state of nature has imposed upon him the necessity of bringing into operation quite as many faculties of mind as the man at his desk; and that, from the brain being exercised in every use to which the external senses are put, its volume is not inferior to that of the individual in civilised life. We must take along with us this consideration, that the exercise of our external senses infers an accompanying activity of brain; that of the nervous apparatus appropriated to the senses, it is the exterior part alone that is given to the eye, ear, nose, tongue; the internal part, forming the sensorium, is in the brain. Remembering this, and that the powers exercised by the savage are not instincts, as in the brutes, but operations of the mind calling the brain into action, I am unwilling to grant that any measurable deficiency in its mass, as a whole, is likely to be perceived. Were it really so, we should find the gamekeeper inferior to his master in a greater degree than my experience warrants."[1] The testimony coming from the most recent research may be seen from the statements of Dr. Herbert C. Major, bearing upon this question,—"to what extent the degree of intellect possessed by an individual during life may be estimated by an examination of the brain after death." He says, it is "a conclusion which we can scarcely avoid, that, as a general rule, great intellectual power is associated with a large and heavy brain. . . . Unfortunately, however, this is by no means an invariable rule, for instances are not wanting in which the brain representing superior intellect has not only not surpassed another, lower in the intellectual scale, but has even fallen below it." Passing next to the number and depth of the convolutions, his testimony runs thus:—"It has been found that increased depth and number of the convolutions coincide in many instances with superior intellectual power. But here again, having arrived at a general conclusion, based on observations which are good and true, we are met by the stern fact that this is not always so, and that instances are not wanting in which the exact opposite is the case." Referring next to the minute structure of the brain, he says:—"When the question arises as to the difference histologically between two brains, one of which represents a high, the other a low standard of intellect, we are compelled to admit that the answer to the question lies beyond our reach." After referring to specific gravity and pathological conditions, Dr. Major presents his general conclusion in the following terms:—"From these considerations it follows that we may have presented to us for examination two brains, equal in size and weight, equal also, so far as can be ascertained, in the number and depth of convolutions—that is to say, in the extent of the grey matter, the latter being also similar in its minute structure, and yet one may represent great intellectual power, the other quite an opposite condition."[1]

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[1] *Anatomy and Philosophy of Expression*, p. 72.

If we compared the skulls of different tribes of men, we should readily recognise considerable difference in configuration. If two brains, belonging to men of maturity, and in a sound state of health, were laid before the most accomplished neurologists, they could not tell the distinctive intellectual power of the two men. Intellectual effort in any man's life depends on personal concentration, continuity of thought, and persistence of wide-ranging reflection. The result is not such as could be estimated according to the cerebral development of the thinker. However good that development be, it would secure little that could be reckoned of special value to the race, without self-directed and continuous effort.

2. *Thought as concerned with the regulation of personal life.*—A self-regulated or rational life is characteristic of man.

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[1] *West Riding Reports*, vol. ii. pp. 157-159.

Government of conduct by intelligence is the grand possibility for men, educated and uneducated. In this we see complete separation of man from all lower orders of beings. Mr. Darwin, as we have seen (p. 241), admits that "we have no reason to suppose that any of the lower animals have this capacity" of "comparing past and future actions or motives, and of approving or disapproving of them." Moral life is regulated, not according to appetite, nor according to outward circumstances, and yet not apart from these, but in view of an ideal standard contemplated and applied. There is no need for here dwelling upon conflicting ethical theories as to the source of our knowledge of moral distinctions. Whether moral law is intuitively known, or is an induction as to general utility founded on the common law of the pleasurable, need not concern us here. All ethical philosophers are agreed in this—that there is a moral standard which men ought to revere and struggle to fulfil. All are agreed that the practical or moral life is, as Aristotle said, "an energy of the soul, according to right reason"[1]—"a kind of well-doing and well-living."[2] It is as a thinker that man shows his superiority in the direction of his conduct. He reflects upon what ought to be, decides for himself the question of personal duty, and acts in accordance with a rational law of activity which he must apply for himself. The overt action resulting from his recognition of duty may readily enough be accounted for under physiological law, but the reflective process which precedes the overt act cannot be so explained. The somatist[3] who would bring all human conduct within the scope of organic action, has here a crucial test of his theory.

If we compel animals to do what we desire, and if by long training we familiarise them with our requirements, we act both upon their fear and their fondness, but the utmost achieved in this way is the result of compulsion, a result which is quickly lost if the external demand be withdrawn. The most enthusiastic upholders of the power of animal intelligence have not suggested that animals reflect upon a rule of conduct. It is, however, the most familiar exercise of human life to consider what ought to be, and afterwards to judge of the extent to which personal obligation has been fulfilled.

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[1] *Nicom. Ethics*, I. vii.

[2] *Ib.* I. viii.

[3] I use the term "somatist" to designate the upholder of the theory that bodily organism embraces the whole nature of man, rather than "materialist," since the latter is resented as implying unmerited imputations.

We must recognise a common experience for man and animal connected with activity; and, quite in advance of this, a special exercise on the part of man, leading to a vastly higher form of action. Both men and the lower animals find a large field of attraction in the outer world; both are acted upon by the qualities belonging to external objects, and thus have their inclinations or desires awakened, impelling them to seek gratification. Under such influence, both have the object of attraction without; both are moved by strong impulse within; and both are inclined to immediate action according to the awakened desire. This common experience may be illustrated by the following figure:—

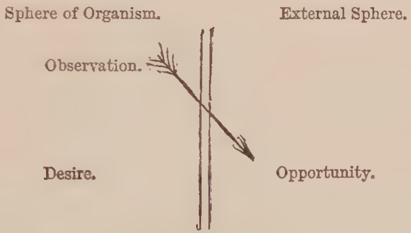

Fig. 49.—Diagrammatic representation of experience of external influence common to Man and Animals.

In the common experience here illustrated, observation is concentrated on the opportunity of gratification afforded by external circumstances. The common result, according to the law of sensitive life, is desire of gratification, and under the same law the common tendency is to seek satisfaction of the desire. The sole law of animal life in such circumstances is active gratification. The sole check on such action is hindrance from without, either preventing gratification or awakening a new impulse, such as fear, which destroys the desire previously aroused. But with man there is a higher possibility, a new and higher source of activity belonging to a more complex nature, an impulse coming from an inner sphere, distinct from the external sphere whence animal life is ruled. There is with man power to consider the desire moving him to seek personal gratification, to reflect upon the rightness of self-gratification in the circumstances, and to hold up before the attention a higher law of life than desire affords. While such power is brought into exercise, the desire, still present, is held in check; and at length, as the result of reflection, the will of the agent may determine the course of personal activity in accordance with a recognised law of rational life, either gratifying the desire, or withholding from such gratification. This higher exercise is illustrated by the following figure:—

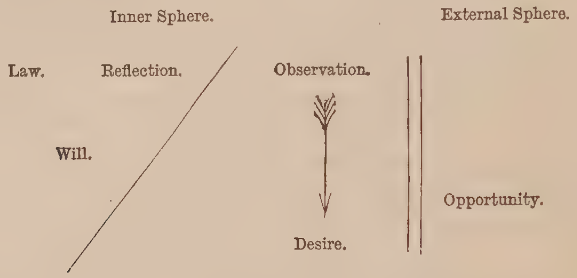

FIG. 50.—Diagrammatic representation of the exercise peculiar to man in governing his Desires.

When attention is directed on the Desire as an impulse to action, and away from the opportunity of gratification, Reflection is turned on the question whether the Desire ought to be allowed gratification, in view of the Laws of rational life, and the Will of the agent becomes the determining power in view of rational law. The only alternatives open to those who would attribute all to organism are, either denial of the possibility of this higher intellectual exercise, or explanation of it under the laws of brain action. It is simply impossible to deny rational exercise as concerned with the guidance of life. The latter alternative is the only one available. But physiology is so far from having surmounted the difficulties here, that it has not even the means of *reaching* the territory in which they are recognised. Discovery concerning sensory and motor nerves, and the laws of innervation, does not include the forms of action to be explained; histological investigation has produced nothing bearing upon the facts. Physiology is not competent even to enter the region of human life with which we are now concerned.

Man does not need to wait for maturity of brain development before he begins to occupy himself with an abstract law of rational life. On the contrary, a child is found concerning itself with rational laws of life, insisting that deceit is wrong, and injustice, and cruelty. A child will judge others, and will condemn them for violation of proper rules of conduct, making no allowance for an old deceiver or oppressor. For abatement of this perplexity, reference is commonly made to the effects of education. But retreat in this direction is of no service, and is clearly an avowal of weakness. A child is the judge of grown men when he pronounces condemnation on pretences and falsehoods resorted to by his seniors. Education may, indeed, do much to influence the thought of a child. It may do much harm as well as much good; under its influence a child may be led to do what it began by condemning. What is called "education," including under that name the influence of the family circle, of society, and of current opinion, may be good or bad according to the direction in which it leads. But some general rules of conduct are implied even in the most confused of the reasonings dealing with moral life. Accordingly, the worst which a bad education can do does not include the satisfying of a child that it is right that he should be deceived.

These considerations lead naturally to a phase of moral life still further in advance, showing the difference between reflection on the law of rational life, and application of it in the government of conduct. This introduces the relation between Intelligence and Will. The possibility of acting according to rational law, in acknowledgment of an authority belonging to it, even against inclination, is characteristic of a rational agent. To make such possibility an actuality is the true end of reflection on duty. By acting under guidance of thought, man rises in the scale of being, illustrating the pre-eminence of rational life. Moral progress thus becomes a distinct test of any theory of human nature. To stand between the allurements of sense and an ideal of rational life; to recognise the duty of giving ascendency to a lofty standard, and to rise by years of patient effort towards this rational ideal; these are possibilities which seem to be altogether inexplicable under a scheme which traces the whole energies of human life to the action of nerve cells.

The contrast between a low and a high type of moral life presents in most striking colours the dominion of sensibility, and the dominion of reason. A life of sensual indulgence means increasing severance from a life of intelligence. The man who moves down on this inclined plane towards the lowest levels of human existence, still shows so much of man's higher nature as to be painfully sensible of his degradation. But as the descent is continued, the exercise of reflection becomes less frequent, and less efficient. The cravings of a disordered nerve system become more clamant and tyrannical; we witness the wreck of human nature, swayed by impulses no higher than those of the animal, involving a condition of physical existence lower even than ordinary animal life.

In contrast we have the progress of the moral life. Deliberate application of rational principle as the guide of human conduct, gives a man mastery over circumstances by gaining control of present inclinations. A life more truly self-regulated is the achievement to be reached. It is possible for a man to ascend far above the level of merely animal life, and the farther he advances in this direction the more obviously does he exemplify the true excellencies of his nature. Rational life implies that impulse may be gratified or restrained according to the decision of the agent, but that thought must govern. There is no call to enter here on a lengthened inquiry as to the merits of the controversy concerning the power of the strongest motive. The question before us can be kept within narrower boundaries. He who would explain moral progress must see the thinker contemplating a law appreciable only to intelligence, and drawing from this contemplation the form of his future career, and the moral purpose which will determine activity, giving ascendency over appetite and passion. These phases of activity belong to an inner life quite separated from the region of sensibility. So complete is this separation that it is impossible that sensibility could afford a scientific explanation of them. They are so obviously superior, involving an actual overruling of personal inclination, that it is impossible to trace their source "to the two elementary functions of sensation and motion, and their conversion into reflex action." It is as a thinker capable of isolating himself from present surroundings, that man is able to take a survey of his past history, to regard it as a whole, to judge of it in the light of a definite standard of human excellence, to mark its deficiency, and to contemplate with satisfaction a struggle to attain a higher form of life. An essential feature in such effort is conflict with the desires and tendencies of the sensitive nature. This is the condition of rational self-government, standing in contrast with the law of sentient life as regulated from without or from the nerve centre.

3. *Thought as concerned with the Absolute Being and His government of the universe.*—Thought directed towards self-government leads naturally on to thought concerning government exercised *over* moral agents. Human thought must advance from lower to higher, and still higher conceptions, until it concerns itself with the Absolute or Self-existent Being, the true source of all finite existence. It is obviously true, as Kant has urged,[1] that an inference from the finite to the Infinite is incompetent, as containing more in the conclusion than the premises warrant. All the more striking, therefore, as testimony concerning the action and range of human thought, is the fact that men have generally recognised as a certainty the existence of an Absolute Ruler of the universe. That the visible suggests the invisible; that the finite suggests the infinite; that the human suggests the Divine, are facts which can be established by a wide induction from the literature of civilised nations and the religious rites of the uncivilised. The scientific value of the religious thought which has found currency in the world is not here the question, but the reality and the possibility of such thought. The marvel to the mind of Des Cartes, when he considered the imperfection of his own nature, and the doubt in which he was often involved as to the certainty of things around him, was the conception he had of an all-perfect Being.[2] The primary question for him was not the existence of God, but the conception of such a being. And the source of this thought

[1] *Critique of Pure Reason*, Meiklejohn's Translation, p. 383.

[2] Des Cartes' *Method*, Professor Veitch's Translation, p. 76.

is the fact to be accounted for by those who refer the functions of mind to organism. The thought of man does not exhaust itself with the materials which observation supplies; does not stop short without a theory of the universe as a whole; it even rises to the conception of an Absolute Being. A theory of the genesis of such thought is the first thing to be supplied. The freest criticism of its validity is legitimate, but nothing can abate the perplexity for the somatist occasioned by the wide-spread belief in the existence of an absolute Ruler. Conceptions of the invisible, the infinite, the Divine, do exist in the world, and have exerted a wide influence in the history of the human race. This fact must somehow be explained; the question is,—Can a physiological explanation be offered?

The scientific thought which seeks to account for antecedence and sequence in the physical world presents the type of thought which widens its problem to embrace all existence, claiming rational explanation of it as a whole. This explanation must be found in the invisible, if we are to explain the visible. The demand for such explanation is in harmony with the accepted results of scientific thought which, with full force of reason, as in recognition of the law of gravitation, accepts the invisible as explaining the invisible.[1] The thought which seeks to account for occurrences in the physical world, proceeds in harmony with the same intellectual conditions, in seeking an explanation of the universe as a whole. The demands of practical life lead directly to the prosecution of similar courses of thought as bearing on personal history. Moral life with its law of rectitude, its obligations and responsibilities, has relations with a sphere of existence transcending the visible. Thus it happens that even the ordinary mind asks the question as to the existence of an absolute authority controlling subordinate existence.

Further, the intelligence which asks this question concerning the origin of things must find its solution in intelligence. We cannot accept as a true cause anything lower than the existence to be explained. Hence the most uncivilised tribes, even with relatively low intellectual development, have never rested in an impersonal God. The intellectual warrant, merely in view of the problem of existence, for regarding the First

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[1] For wider application, see *The Unseen Universe.*

Cause as Absolute Intelligence, is clear. As Sir William Hamilton has said, "We have only to infer, what analogy entitles us to do, that intelligence holds the same relative supremacy in the universe which it holds in us, and the first positive condition of a Deity is established."[1] So, physical, intellectual, and moral existence become harmonised in the problem which common intelligence recognises as to the origin of the universe. Contemplating in this way the totality of finite existence, Dr. M'Cosh has well said, "As the physical requires the moral, so the moral requires the physical as its complement, in giving a full exhibition of the character of God, and of his administration in reference to our world."[2]

Once more, in considering the problem of existence, it is manifest that everything finite is held to require an explanation of its existence. The finite is the dependent. Scientific thought cannot find a resting-place in "an infinite regress of finite causes" any more than unscientific thought can find the explanation of events in carved figures, uniformly named "gods," and multiplied for the use of the families of a tribe. The conception of an infinite series of dependent existences, which depend on nothing, or depend only on one another, must be banished from thought as incongruous. But it cannot disappear without contributing its share of testimony to the fact that the human mind deals with the conception of the infinite, even in attempting to construct the impossible combinations of an infinity of finite existences. The finite suggests the Infinite. And, though it is true that the existence of an infinite and absolute Being is not the product of an inductive process, the conception of such a Being is familiar to the human mind, and is fitly regarded as the only rational explanation of existence, every conceivable alternative, atheistic, pantheistic, polytheistic, being convicted of irrationality.

In accordance with this view, it is established on ample evidence that there is no tribe of men ascertained to be destitute of religious belief. Dr. Edward B. Tylor, in his work on *Primitive Culture*, has accumulated a mass of evidence drawn from all sources as to the religious beliefs of uncivilised tribes. Dr. Tylor seeks a general characteristic of religious belief, applicable as a test to the records of travellers, missionaries, and residents amongst the lower races. He takes, "as a minimum definition of Religion, the belief in Spiritual Beings."[1] He says, "I propose here, under the name of Animism, to investigate the deep-lying doctrine of Spiritual Beings, which embodies the very essence of Spiritualistic as opposed to Materialistic philosophy."[2] "Animism characterises tribes very low in the scale of humanity, and thence ascends, deeply modified in its transmission, but from first to last preserving an unbroken continuity, into the midst of high modern culture. . . . It is habitually found that the theory of Animism divides into two great dogmas, forming parts of one consistent doctrine; first, concerning souls of individual creatures, capable of continued existence after the death or destruction of the body; second, concerning other spirits, upward to the rank of powerful deities."[3] "Thus Animism, in its full development, includes the belief in souls and in a future state, in controlling deities and subordinate spirits, these doctrines practically resulting in some kind of active worship."[4] These quotations are sufficient to show upon what basis Dr. Tylor rests his judgment. And his testimony is the following:—"Here, so far as I can judge from the immense mass of accessible evidence, we have to admit that the belief in spiritual beings appears among all low races with whom we have attained to thoroughly intimate acquaintance; whereas the assertion of absence of such belief must apply either to ancient tribes, or to more or less imperfectly described modern ones."[5] "Thus the assertion that rude non-religious tribes have been known in actual existence, though in theory possible, and perhaps in fact true, does not at present rest on that sufficient proof which, for an exceptional state of things, we are entitled to demand."[6]

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[1] *Metaphysics*, vol. i. p. 31.

[2] *Method of the Divine Government*, p. 448.

It is, therefore, in accordance with a vast mass of evidence that Mr. Herbert Spencer speaks of the "omnipresence of the beliefs," saying that "religious ideas of one kind or other are almost if not quite universal."[7] These beliefs as to the existence of Deity and a future existence for the soul may with accuracy be described as "beliefs that are perennial, and nearly or quite universal."[1] Excluding the apparent exception of certain tribes, the following passage presents the competent inference from the facts: "Grant that among all races who have passed a certain stage of intellectual development, there are found vague notions concerning the origin and hidden nature of surrounding things; and there arises the inference that such notions are necessary products of progressing intelligence. Their endless variety serves but to strengthen this conclusion,—showing, as it does, a more or less independent genesis,—showing how, in different places and times, like conditions have led to similar trains of thought, ending in analogous results. That these countless different yet allied phenomena presented by all religions are accidental or factitious, is an untenable supposition. A candid examination of the evidence quite negatives the doctrine maintained by some that creeds are priestly inventions."[2] We are not here concerned with the measure of truth which may belong to the beliefs of uncivilised tribes, but with the possibility of such belief concerning Divine existence, and such expectations of futurity of being as are found everywhere existing. Even the most barbarous tribes now existing are not far removed from the level of religious creed which obtained among the ancient Greeks and Romans. Such beliefs and expectations are, therefore, compatible with the lowest forms of uncivilised life, and with an utter absence of education.

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[1] *Primitive Culture*, vol. i. p. 424.

[2] *Ib.* vol. i. p. 425.

[3] *Ib.* vol. i. p. 426.

[4] *Ib.* vol. i. p. 427.

[5] *Ib.* vol. i. p. 425.

[6] *Ib.* vol. i. p. 418.

[7] *First Principles*, p. 13.

At an immense distance from such thought, yet in logical harmony with it, we have the lofty speculations of philosophic thought, dealing with the same problems, and moving along the same lines, but rising to heights which many educated men cannot appreciate. Whether this higher range of thought be regarded as an intellectual and moral reaction against the admixture of the irrational and wicked with religious belief and practice, or as a more purely speculative effort rising from the facts of the universe, and aiming at the construction of a rationalised scheme of existence, its testimony seems equally powerful in support of a distinctly intelligent nature, having a field of action all its own, and yielding results quite beyond those which can follow from the functions of organism. Thus we have the discriminating and massive thought of Socrates seeking for the rational conceptions which should govern human life;[1] and the protest of Plato against the lies of the poets who represented the gods to be deceitful and profligate;[2] and his more adventurous speculation concerning essences of things, and the Good, which is more than essence, being the source of all.[3] In modern times we have the whole movement of philosophic thought, concerning itself with the nature and functions of pure reason, in contrast from all that is involved in mere sensibility and motor activity. This movement had its rise when Des Cartes sought for certainty in self-consciousness. Its leading conception was indicated by Spinoza, when he proclaimed "what the true method must be, and wherein it chiefly consists, viz., in a knowledge of pure intellect alone, its nature and its laws."[4] Spinoza seeking to deduce a complete scheme of the universe from the conception of a self-existent, all-embracing unity; Kant distinguishing between the elements of knowledge which come through experience and those which come from the mind itself; Hegel, proceeding from nothing by dialectic evolution to reach absolute unity in the true Infinite,—all unite in testifying to the power of an intelligence far transcending the mechanism of the nerve system. To criticise these schemes of thought, or estimate their philosophic value, does not form any part of the present plan, any more than to test the worth of the cruder thoughts of uncivilised men. We turn attention on these schemes of speculative thought as products of the human mind, affording profound interest to many who are occupied with the intellectual requirements of a scheme of existence. We merely place in position a typical illustration of the higher efforts of human intelligence. We witness the concentration of thought on the problem of being, the elaboration of an intellectual scheme in accordance with our conceptions of the government of an invisible, infinite, and absolute Deity, under which moral excellence is of more value than many worlds.

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[1] *First Principles*, p. 4.

[2] *Ib.* p. 13.

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[1] Xenophon's *Memorabilia*, B. iv. ch. vi.

[2] *Republic*, ii. 381.

[3] *Ib.* vi. 509.

[4] Spinoza's *Life, Correspondence, and Ethics*, by Willis, p. 329.

CHAPTER XVI.

SUMMARY OF INTELLECTUAL RESULTS.

A BRIEF outline will suffice for a summary of those forms of activity which illustrate the functions of Mind as distinguishable from those of Brain.

Beginning with sensation, there are not only successive sensations, but we compare a present sensation with sensations previously experienced. In this way a knowledge of the qualities of objects is obtained, which could not be reached without memory and judgment. In each phase of experience, there is a knowledge of Self, as distinct from sensation; and through the successive stages of experience there is a knowledge of Personal Identity, or the unity of personal life.

When we pass to Motor Activity, the aspect of personal existence is at once widened. Apart from the activity of motor apparatus as stimulated by the sensory apparatus, there is Self-originated action, or motor activity depending on our own intelligent purpose. In this, the distinction between Self and the particular action of the moment is preserved. In this case we know Self as an agent in the world,—the cause of personal activity,—an agent operating according to the movement of an intelligent nature. And here also, we have a knowledge of continuity of existence,—a knowledge of personal identity, carrying with it personal responsibility for our conduct.

It further appears that there is a phase of personal activity in the use of Memory. We must discriminate between retentiveness, and what by contrast is more properly recollection. Recollection is a phase of activity, voluntary or involuntary, resulting in a reproduction or re-presentation of what has previously had a place in consciousness. In its highest and most striking forms, it illustrates the action of Intelligence and of Will. Under the laws of association, there may indeed be involuntary recollection; but a voluntary activity as involved in recollection specially engages our attention here. Knowledge to be surely stored must be the object of careful discrimination; recollection making such knowledge available in the present, implies intelligent use of distinctions previously recognised, and personal application of the laws of association for the end contemplated.

In these three outstanding facts, intelligent use of sensibility; intelligent direction of motor activity; and intelligent use of a power of recollection, we have the distinguishing features of the earlier stage of human intelligence. In these appears the immense superiority of the child over all lower orders of animate existence. The child's life is a personal life. From the first he thinks and speaks of Self as the centre of knowledge and activity. In harmony with this, the recollections of his past life are constantly referred to, and the expectations of the future are cherished.

This life is seen to widen and deepen under the additional advantages which Speech implies. In a child's life, the vocal organs are used as the expression of personal life, language becoming the medium of nourishment for such a life. Speech is at once an index of the power of intelligence within the child, and an instrument for its development. The senses are, indeed, the primary educators. But the senses have their influence multiplied incalculably, by association with vocal organs, and with all that is involved in their intelligent use. Eye and ear with intellect contribute greatly more towards the enriching of personal life than sensory impressions. Intelligence makes these senses, instruments of real knowledge in a much higher degree than they could be by their mere natural functions. Speech in addition affords egress for intelligence, which is quickened and strengthened by expression of thought. To be dumb is to be restricted to a more contracted range of intelligent activity. Hence physical defect connected with the vocal organs is made up for by use of visible signs, which are the contrivances of intelligence to overcome the disadvantages of physical restraint. The need of the intelligent nature for expression is thus made more manifest, and we are taught to estimate more highly the important advantages which are apt to be overlooked, on account of our familiarity with them. Though speech is primarily a physical acquisition, it is in reality an intellectual attainment, and becomes an instrument providing for action and reaction of mind upon mind in a community of intelligent beings.

The higher significance of personal life appears, when next we contemplate the self-regulated life in all its leading phases. The possibilities of human life are to be measured by the possible concentration of thought; its achievements by the degree in which such concentration has been attained. From lack of concentration, all the possibilities of high brain development have been associated with a dissipation of mental energy, resulting in a life which could not be described otherwise than as a failure. By concentration of thought, physical life has gained the advantages flowing from large appreciation of higher laws of self-regulation, leading to triumphs of self-mastery.

Human nature is a unity, and so also is human life, to be regulated by the Imperative of Moral Law. Greatness in human life appears in the degree in which moral law holds sway over it, spreading from it an influence encouraging and helpful to others.

A still higher range of intellectual activity is concerned with explanation of the universe as a whole, including a view of the responsibility and destiny of the rational being, in accordance with recognised superiority of moral life. This is a range of thought due to the acknowledgment that all finite existence needs explanation, and that of finite existence, moral being presents the governing consideration in the problem. A rational nature finds the explanation only in an Absolute Being, of infinite intelligence and absolute moral excellence.

In these three departments of intellectual activity we have a harmonious view of intelligent life.

The nature of Mind is clearly indicated in its functions. It cannot be explained under the conditions applicable to matter. That there is much in the nature of mind greatly beyond our own powers of interpretation may be freely granted. This has been recognised by the physiologist, as admitted by Dr. Maudsley :—“ Entirely ignorant as we are, and probably ever shall be, of the nature of mind, groping feebly for the laws of its operation, we certainly cannot venture to set bounds to its power over those intimate and insensible molecular movements which are the basis of all our visible bodily functions, any more than we can justly venture to set bounds to its action in the vast and ever progressing evolution of nature of which all our thoughts and works are but a part. . . . In the microcosm of the body, which some ignorantly despise, there are many more things in reciprocal action of mind and organic element than are yet dreamt of in our philosophy."[1] A true philosophy will never despise the body, or set lightly on man's relation to Nature,—the great Kosmos of which we form a part. But, if man's nature is the greatest thing within this Kosmos, it is the rational life of man which constitutes his greatness. Man's nature is a microcosm, representing the material and the mental. Whatever we may say of the "intelligence" of animals, with the marvellous possibilities of an intricate coordination of the apparatus belonging to the special senses, there is an immeasurable distance between them and man, who alone recognises the rational all around. Contemplating his own nature, he anticipates continuance of his life, distinguishing between a perishable and an imperishable. He recognises a life of the body, progressive from youth to maturity, after that declining downwards to decay. But there is a life of the mind, progressive as life advances, and, even after physical maturity is past, progressive in respect of enlarging knowledge, loftier attainment, and clearer expectation of a life beyond, bordered by no dark shadow of death. In harmony with these expectations which moral life cherishes, the philosophic spirit has said,—" there is a change and migration of the soul from this world to another,"—in accordance with which it says fearlessly,—" Know this of a truth, that no evil can happen to a good man, either in life or in death."[2] Still more fully in harmony, shining in a clearer light, is the testimony of Christianity, bringing " life and immortality to light through the gospel,"—recognising that Science and Philosophy must be achievements of men, while God Himself has given direct assurance of an immortality beyond the visible.

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[1] *Body and Mind*, p. 38.

[2] Plato's *Apology*, 40, 41.

APPENDIX.

HYPNOTISM: ITS NATURE AND ITS TESTIMONY AS TO THE RELATIONS OF MIND AND BODY.

The phenomena of Hypnotism, or artificially induced nerve-sleep, popularly known as "mesmeric," are now receiving a more careful scientific investigation than they have hitherto had. Friedrich A. Mesmer, born in 1734, near Meersburg, in Baden, turned attention to artificially induced sleep, under influence of magnetism. He attributed the effects to the action of the heavenly bodies (*De Planetarum Influxu*, 1766). He publicly illustrated his use of magnetism in Paris from 1788, introducing references to "animal magnetism." His latest account of his theory was published 1799. For a season "animal magnetism" was the agency to which the phenomena were attributed. Joseph P. F. Deleuze, born at Sisteron, Lower Alps, 1753, having his attention turned to these phenomena, went to Paris in 1785 specially to study them, where he was appointed naturalist to the Botanic Gardens. In 1813 he published his *Critical History of Magnetism*, and in 1825 his *Practical Instruction in Magnetism.* His view was that a magnetic influence, belonging to the vital principle, passed from one person to another. He named it "the magnetic fluid." He regarded its transference as the natural explanation of the phenomena. It was in 1842 that Braid, a medical practitioner in Manchester, trained in the University of Edinburgh, published an inquiry into the rationale of nervous sleep, turning attention from magnetism to the laws of nerve action.[1] Recently, attention has been largely given to this subject, as the result of attempts to ascertain the effects of nerve-sleep in cases of disease. In Paris and Nancy, in Berlin and other German Universities, as well as in Britain and America, experiments have been prosecuted. In

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[1] *Neurypnology; or, The Rationale of Nervous Sleep.* By James Braid, M.R.C.S.E.

1889 a representative congress assembled in Paris for discussion of the subject. In the same year, the British Medical Association, meeting in Birmingham, unanimously appointed a committee of inquiry "with the object of endeavouring to ascertain the true nature of the phenomena, and the propriety or otherwise, and the value, of its use in the treatment of disease."

The most important preliminary is a careful statement of clearly ascertained facts. This must supply the basis for all departments of inquiry. While medical science is concerned with the value of the facts for therapeutics, ordinary scientific interest concentrates on their significance as bearing on the laws of sensory experience, on the normal action of mind, on the relations of mental action to bodily functions, and on the regulation of personal life.

The observations of Charcot, Luys, Doumontpallier, Binet and Féré in Paris, and of Liébeault and Bernheim in Nancy, of Forel in Zurich, of Moll, Dessoir, Sperling, Preyer, and Baierlacher in Germany, along with those conducted in Britain and America, afford ample materials on which to rest our conclusions.

The hypnotic condition is that of sleep artificially induced, through concentrated and constrained action of some sensory nerve fibre, with its co-ordinated muscular arrangements. Commonly the nerves of vision are chosen, as directly concerned with sleep, and most easily operated upon. Bernheim states: "Many patients are hypnotised, although they do not sleep," and adds that in some cases "only a rigid fixation of the eyes results." (*Suggestive Therapeutics*, p. 2.) The hypnotic state is, however, induced in a variety of ways. In some cases a person is thrown into the nerve-sleep by a quivering movement of the outstretched fingers of the operator in close proximity with the eyes of the patient; in others by passes of both hands of the operator brought from behind over the head of the patient so as to cover the eyes during the continuance of the process; in others, there is resort to a form of fascination through the eye of the operator; in others still, the eye is fixed on a selected point, on a coin in the hand, on a spot on the wall, or on the top of an object on the table.

The school of Nancy, while resorting to the use of the fingers and eyes of the operator, assigns chief value to suggestion. Bernheim even says: "It is sleep by suggestion,—a type of sleep which I insinuate into the brain" (*Sug. Therap.*, p. 2); it is often induced "without passes or fixation." Deleuze early remarked "the salutary effect of gentle frictions" (*Practical Instruction in Animal Magnetism*, p. xiv.). Courmelles says:—"It has been discovered that certain parts of the skin—the forehead, the ear lobe, the arm and the back—when pressed, induce sleep" (*Hypnotism*, p. 73). In the somnambulistic state the skin "acquires an exquisite sensibility" (Binet and Féré, *Animal Magnetism*, p. 127). "It is possible to limit this to a definite region by exciting the scalp in different ways," p. 128.

In most of the methods adopted there is an attempt to weary the organs of vision so as to induce sleep. Braid fixed the gaze of the individual on "any bright object" held "at such position above the forehead as may be necessary to produce the greatest possible strain upon eyes and eye-lids, and enable the patient to maintain a fixed steady stare at the object," the patient keeping "the mind riveted on the idea of that one object" (pp. 27, 28). Carpenter holds that the mere convergence upwards of the eyes is sufficient. Bernheim says: "The fixation of a brilliant object, so that the muscle which holds up the upper eyelid becomes fatigued, and the concentration of the attention on a single idea, bring about the sleep" (*Sug. Therap.*, p. 111). Recent experiments have shown that stimuli of sight, hearing, and touch may all contribute towards the result. Concentration of eyes and mind on one object till the eyes are wearied by the exercise, is characteristic of the methods commonly employed. Luys in Paris fixes the eyes on rapidly revolving mirrors. The school of Nancy has specially insisted on the value of suggestion from the operator, a kind of "suggestive education," awaking anticipation in the patient, thus directly connecting action of intelligence with production of sleep, and with experience under its dominion. Experimenters seem to have carried this too far, even suggesting to the patients that they "have no will" (Bernheim's *Sug. Therap.*, p. 3). With some patients it is admitted that "quiet suggestion has no effect" (*Ib.* p. 3). The hypothesis that a species of magnetic current, or vital influence, passes from the fingers of the operator to the eyes of the patient must be abandoned, in consequence of the variety of methods employed, specially when taken with the fact that the sleep may be self-induced (Braid, Pref. xix.).

The hypnotic state is an artificially induced and abnormal nerve-sleep. Such sleep is gradually brought on, and is capable of being greatly deepened. Its simplest phase is that of quiet lethargic slumber. An advanced stage illustrates an abnormal physical condition, the muscles, being first relaxed, tend to become rigid as in a cataleptic state. "Lethargic contracture presents some characters which clearly distinguish it from a voluntary contraction" (*Animal Magnetism,* by Alfred Binet and Charles Féré, p. 114). "If the contracture is left to itself, it will continue throughout the lethargy" (*Ib.* p. 115). In a third stage the patient becomes a somnambulist, acting under direction of the operator, as if he were awake, and were freely exercising sensory and motor power. The first stage gives the key to the situation. The last stage shows the mind in full action, notwithstanding the state of sleep. Bernheim says: "I define hypnotism as the induction of a peculiar psychical condition which increases the susceptibility to suggestion" (*Suggestive Therapeutics,* p. 15). Kingsbury says: "The great essential feature of hypnosis is not sleep, but a heightened receptivity of suggestion with or without sleep" (*Practice of Hypnotic Suggestion,* p. 19). Both of these definitions omit reference to the state of the nerve system, without which there is no hypnotism.

"There is a remarkable difference in the degree of susceptibility of different individuals to the hypnotic influence, some becoming rapidly and intensely affected, others slowly and feebly so" (Braid, Pref. xii). As to the effects produced, "we have the extremes of insensibility and exalted sensibility, of rigidity and mobility, at different stages, and these merging into each other by the most imperceptible gradations, or in the most abrupt manner, according to the mode of treating the patient. At a certain stage the transition from torpor of all the senses and cataleptiform rigidity to the most exalted sensibility and flaccidity of muscle, may be affected almost with the celerity of thought, even by so slight a cause as a breath of air directed against the part" (Braid, Pref. xii, xiii).

Considerable diversity of opinion exists as to the number of persons liable to hypnotic experience. Observations have been based on the comparative number of those presenting themselves in public who do not come under dominion of the operator. Such observations afford no accurate test, because the conditions are unfavourable to slumber. The same objection applies in the case of those consulting a medical practitioner. If we are correct in holding that the state is one of artificially induced sleep, commonly caused by wearying the organs of vision, aided by action on other sensory stimuli, and by the suggestion of the operator, there cannot be ground for maintaining that there is any large number of persons not liable to be affected in this way. The sleep is induced under conditions of sensibility common to the race. There may be greater liability in some cases than in others, but the possibility must be common. Dr. Felkin supports this view, *Hypnotism, or Psycho-Therapeutics*, p. 11. Bernheim declares that "all or nearly all the patients in a ward fall under the dominion" (*Suggestive Therapeutics*, p. 7). Liébeault's table for 1880 shows only twenty-seven failures out of 1012 patients experimented on.

Liability to nerve-sleep may be greatly increased by frequent resort to the means producing it. In this way a person in good health may induce morbid sensibility. Such sensitiveness is apt to prove unfavourable to health, and to be otherwise injurious. The section of Psychology of the British Medical Association had, therefore, ample warrant for condemning public exhibitions experimenting on the nerve system. The terms of their resolution are these: "This section protests in the strongest manner against public exhibition before unscientific and miscellaneous audiences, and for purposes of gain or amusement, of the phenomena of hypnotism,—a practice which, in the opinion of this meeting, is antagonistic to public morality." The strength of reason supporting this decision will appear as we proceed. This judgment is generally sustained by competent authorities. In France, both the Minister of War and the Minister of Marine prohibited the practice of hypnotism in the public service.

Interest concentrates largely on results obtained after nerve-sleep has been induced, when an operator proceeds to direct the *action* of the sleeper. "In all degrees of hypnosis the subject hears and understands everything, even though he may appear inert and passive" (Bernheim's *Surg. Therap.* ix). Suggestion from the operator takes the place of ordinary sensibility and induces conscious purpose. It dominates sensibility and purpose, guiding both; but it does not displace the one any more than the other. Intelligence interprets the suggestion, which is voluntarily acted upon as if it were an index of reality such as we receive through the senses. The consequence may be a complete reversal of the sensory experience belonging to ordinary life, to the extent, for example, of producing a sense of sweetness while eating what is bitter. This illustrates the most striking results of suggestion communicated to the mind in course of the nerve-sleep. These are (1) subordination of sensory impression to the intelligence and imagination of the sleeper; (2) ready acceptance of suggestion from the operator as affording ground for action. In the same way, during ordinary sleep, dreams can be shaped by suggestions whispered into the ear of the sleeper by a familiar voice (Abercrombie's *Intellectual Powers*, p. 271). Facts connected with hypnotic somnambulism afford striking testimony as to the reaction of physiological habit on mental experience. If the body of the somnambulist be thrown into an attitude naturally expressing strong emotion, such as wonder or fear, the subject will be influenced accordingly. This is an example of "motory suggestion." On the other hand, mental action awakens sensory impression of any kind, under the leading of suggestion. Vivid representation in the mind can awaken sensibility at variance with natural physiological results. It is with the subject as with a quiescent mind in ordinary social intercourse, unquestioningly accepting and acting upon the suggestion of a familiar friend. In the cataleptic state the subject is unfitted for action; in the somnambulistic, he is the voluntary agent in lucid sleep ready for action.

When the whole range of suggestion has been placed at the disposal of the operator, and is used without the least regard to truthfulness of representation, results unnatural and quite ludicrous are easily obtained. The disturbing cause is in the operator, not in the patient. The sleeper is not irrational, he is only off his guard. He is impressible, readily accepting representations made, as one would do in unquestioning acceptance of a statement. The true marvel is that when nerve-sleep has been induced the mind readily interprets the utterances of another.

As soon as sleep has been established the possibilities of deception are great. The sleeper may act as if sensory impressions received had no place in experience, or even as if they were exactly the reverse of their real character. Bernheim says (*Suggestive Therapeutics*, p. 29), "General sensibility and the special senses may be modified increased, or perverted at will. I put salt into the subject's mouth, telling him that it is sugar. Some subjects do not accept this suggestion perfectly. They will perceive the salt taste, more or less clearly. Many, however, suck the salt with pleasure, finding it very sweet. . . . The most curious illusions may be suggested. A pencil put into the mouth takes the place of a cigar, the aroma of which he draws in with pleasure, blowing puffs of imaginary smoke into the air." These abnormal impressions take their character from the suggestion of the operator. The conceptions introduced to the consciousness of the sleeper are interpreted as under the usual conditions of experience. The ordinary tests of reality are in abeyance; consequently representations made are unhesitatingly accepted and acted upon. If a third person is in the room when the patient passes into the sleep, the operator has only to say that their friend has gone, in order to secure that the sleeper shall cease to recognise a third person. He may see all else in the room, but he will no longer see his friend there. If he be directed to walk towards an object beyond where the third person stands, he will not recognise him, yet will guide his own movements so as to avoid collision. It is thus apparent that there is not inaction of the sensory, but its use is dominated by the belief established in the mind, the attention not being disturbed even by impressions made on the senses. There is concentration of attention in harmony with the representation given. When a person is said to be absent, he is held to be absent, and the exercise of vision does not unsettle this persuasion. Nevertheless, the presence of an object is clearly recognised. To avoid collision, yet not to "recognise" the person—not to make further account of his presence than change of direction implies, as if the friend were only a block in the way, is the index of an absorbed mind. We have here an example of "absent-mindedness," which does not mean an unoccupied, but a preoccupied mind. Attention has been averted by a belief accepted as true.

The more frequently this nerve-sleep is induced by the same operator, the more dominant does his influence become. His suggestion gains ascendency over the voluntary action of the patient. This may, indeed, become an established dominion, not only during the nerve-sleep, but even over the life in the waking state. This is not a direct consequence of the sleep itself; it is the result of an association established by the procedure of the operator, and is capable of being confirmed at his pleasure. Ordinary intellectual action becomes associated with abnormal brain excitement, and conduct is regulated with implicit faith in the operator. According to the laws of association, his influence tends to become a fixed dominion, incompatible with normal self-regulation.

In the history of this dominion the sleeper may, after a time, be led on to action, notwithstanding hesitation, or even actual aversion, because of disapproving the act suggested. Thus, to take a single example given, when the operator tells the sleeper that he is about to say something disrespectful or rude, the subject will first say that he would not do such a thing, will thereafter show signs of hesitancy, and will at length fulfil the suggestion. Dominion over the better feelings can thus be induced, leading to violation of rules of conduct adhered to in the normal state. Here there are only two limits—what suggestions the operator will present, and what force of aversion the patient can endure without disturbance of the hypnotic state. In the sleeper, faith is as confiding as that of an unsuspecting child ; yet character and temperament remain as before. Cases are recorded of resistance to suggestion even so determined that suggestion of inability to speak had to be audibly reversed (Courmelles, *Hypnotism*, p. 210 ; Felkin's *Hypnotism*, p. 27). For bearing of this on localisation, *vide* Bateman, *On Aphasia*, 2nd edition, p. 334.

These few examples illustrate the class of facts with which we have to deal. That the facts are as stated has been placed beyond doubt. How we are to account for physical changes resulting from the nerve-sleep, affecting both nerve system and muscular, affecting respiration and circulation, is a question still unanswered. How it should happen that a nerve-sleep, induced by wearying out or fascinating the organs of vision, and straining the motor nerves, should induce a muscular disturbance readily passing to a cataleptic extreme, is an unsolved problem in physiology. The evidence tends to show that the integrity of organic life depends upon a balance of nerve-action, sustained by continual change in the distribution of nerve-energy, thus avoiding persistent strain in one direction, which soon proves irksome and disturbing to the whole nerve system. Nerve-sleep resulting from such strain invariably occasions organic disturbance. As is well said by Courmelles, "the phenomena presented by hypnotism are always exceptions" (*Hypnotism*, Pref. viii). In this state, the mind, still working according to the ordinary laws of association, accepts the guidance of the hypnotiser. To the ordinary observer, lacking the experience of the professional expert, it seems as if the nerve-sleep may be found to have some value in medical practice when dealing with nerve disorders, by presenting a nerve condition favourable to the application of curative agency, and stimulating expectation of recovery. To the moralist it will appear that the practice of the operator must be truthful and honourable in the highest degree, if he and the patient are not to suffer moral injury. Dr. Voisin, in his report to the Paris Congress in 1889, well said: "I think that we must lay down as an absolute principle, never to suggest an illusion, an hallucination, an evil thought, or a bad or mischievous action, to a hypnotised subject." On the other hand, regard to personal responsibility should deter every one from subjection to the control of another under the abnormal conditions described, unless it be for reasons analogous to those leading us to seek direction of a medical practitioner.

The bearing of the phenomena of hypnotism on the action of Mind is much more clear than their relation to organic effects. The mental facts, including the suggestions of the operator, and the consequent actions of the patient, are sufficiently under ordinary observation to admit of a judgment being formed as to their significance. Their relation to the action of the sensori-motor system may thus be clearly made out.

It is necessary to distinguish carefully this artificial sleep from ordinary slumber, admitting that they have a common basis in physical quiescence or torpor. Hypnotism is described by Braid as "merely a simple, speedy, and certain mode of throwing the nervous system into a new condition" (p. 4). The effect is not unfitly named a "lucid sleep," agreeing in some respects with natural sleep. The analogy is manifest, yet the difference is great. In both cases a state of torpor is established. But in the one case a natural repose of the whole body follows upon natural exhaustion of the whole physical system. In the other, weariness and sleep are partial; these are artificially induced, and this in a manner alien to the ordinary laws of nerve action. The natural diffusion of nerve-energy is interfered with, nerve-energy being voluntarily and designedly concentrated, in order to cause weariness of a selected set of nerves, and to induce sleep as a consequence. The effect within the nerve system is described by Braid as " paralysing nervous centres in the eyes and their appendages, and destroying the equilibrium of the nervous system " (p. 16). Instead, therefore, of a quiescence under which a general physical inaction is induced, as in ordinary sleep, there is an artificial sleep throughout which physical and intellectual activity are readily prolonged under direction of an operator. An intensity of sensibility quite unknown under ordinary conditions is often manifested, under the influence of external suggestion.

What would be the results if the quiescence natural to slumber were maintained undisturbed, we have too slight evidence to show. Experimenters have been so eager to ascertain what the sleeper can *do*, that we have had small chance of seeing what physiological gain there might be from the slumber itself. The evils of insomnia should suggest the importance of observations for ascertaining the recuperative value of the hypnotic state. Such observation finds preliminary encouragement from the fact that in the nerve-sleep, notwithstanding exceptional cases, there is a natural tendency to quiescence, though we have sufficient warning that incessant activity during the slumber tends to exhaust the whole system. The inquiry as to the refreshing power of nerve-sleep is one of the most important still to be prosecuted. Braid testifies that " the artificial somnambulists have an inclination to remain at absolute rest, unless excited to action by some impression from without " (p. 44). This is fully sustained by recent observations, and is strongly maintained by the school of Nancy. Bernheim says : " The patients in deep sleep, with loss of memory upon waking, lie quietly like natural sleepers, if let alone " (*Suggestive Therapeutics*, Pref.). In the lethargic phase " the subject presents the aspect of a person in a deep sleep " (Courmelles, *Hyp.*, p. 75). " When hypnotism has been induced, the subject generally awakes naturally at the end of a very short time " (*Ib.*, p. 76). In cases of spontaneous hypnotism the sleep is apt to be more protracted. Such cases show a threatening of paralysis. I incline to think that the physical risks connected with the sleep have been exaggerated by persistent experimenting as to possible activity.

The quiescence of the nerve-sleep offers in itself no obstacle to activity when suggested by the operator. This sleep has been established on an accepted understanding, which continues to be recognised after sleep has begun. Acute mental activity is a common characteristic in this state, for which, indeed, there is obvious preparation in expectations previously awakened. No physiological hindrance is encountered because of sleep; indeed, the brain seems prepared for special activity. Accordingly, when the state of quiescence sets in, the whole situation favours manifestation of feeling and disposition, without reserve or natural restraint, as when the criticisms of those around are regarded.

For interpretation of the phenomena, increased attention must be given to the manner in which the sleep is induced. There is uniformly a phase of *fascination*, but there is great diversity in the manner and measure in which this is exercised. To these diversities in causation much more attention must be given than has yet been directed upon them. Especially must a broad distinction be drawn between the results when sleep has been induced only by concentration on a point of observation; and those obtained when an operator intervenes, exercising personal fascination before sleep, and communicating suggestions after sleep has begun. While the sleep itself is the same, conditions and results are entirely different in these two cases.

The first hypnotic effects are entirely physical. This calls for modification of the statement by Albert Moll, "that the bodily functions show a deviation from the normal, purely as a consequence of psychical states" (Moll's *Hypnotism*, p. 53); and that of Bernheim: "It is suggestion that rules hypnotism" (*Suggestive Therapeutics*, p. 12). Bernheim afterwards says: "The hypnotic state and its associated phenomena are purely *subjective* in their origin" (p. 111); but what he means by "subjective" appears from the last clause of the sentence; that "which is in the nervous system of the subject." A merely physical exercise is sufficient to occasion nerve-sleep without resort to suggestion. Results are in the first instance concerned specially with the nerves of vision, and with the localities of brain with which these are actively related. The sleep has its seat here, and it seems as if its range were at first somewhat restricted in this way. If the state of sleep were regarded as the end, and no attempt were made to carry the sleeper into activity, dominion of the sleep would gradually extend, resulting only in general quiescence of the organism. Ocular fascination, such as that produced by revolving mirrors with incessantly changing reflections, involves a purely physical influence causing a purely physical result. The only mental element involved is the deliberate purpose of the person who fixes his eyes, and concentrates his attention accordingly. Without such voluntary determination the sleep could not be induced, for it is not a natural somnolence capable of arising under ordinary conditions of activity. In respect of dependence on voluntary determination, Moll's statement is fully warranted. Yet is the sleep itself essentially a physical result. All the phenomena which have roused popular curiosity depend on suggestion afterwards.

We pass into a distinct and much wider field of observation when the patient's quiescent state makes room for intervention of the suggestions of an operator as director of subsequent experiment. This involves much more than an *extension of the area* of experiment; there is a complete *change of the centre* of experiment, by voluntary transference of the direction of conduct from self to another. The significance of this change is great. Without it, we could not have the phenomena described. The large range of intervention granted to an operator must be clearly recognised, if we are to understand the consequences. The conditions in the two cases are very different. The surrender of one's-self to sleep is in every sense natural. To resort further to voluntarily selected means for inducing sleep is quite within the scope of legitimate self-direction. But if we surrender ourselves into the hands of another that he may induce sleep, and may, during its continuance, experiment on our susceptibilities, physical and mental, we place our life—our whole personality, body and mind—as an *instrument* at his disposal. A serious moral responsibility is thus involved for both patient and operator—a responsibility unnatural in any case, and capable of vindication only as a temporary expedient for securing a large gain to life.

Apart from this preliminary ethical question, we now follow the experimenter into his field of action. The personal influence of the operator here becomes the chief agency. Everything pertaining to such influence, suitable for promoting the contemplated end, is brought to bear upon the patient voluntarily placing himself in the subject position. The powers of fascination belonging to the eye, to the expression of emotion coming and going on the countenance, to selected and combined sensory stimuli, and to suggestions presented to the mind, are brought into combination. It is a striking fact, showing the value of sensory stimuli, that after the lethargic state has been induced, merely "by lifting up the eyelids, the light in some way illumines the brain and endows it with new virtues" (Courmelles, *Hyp.*, p. 83). Stimulation of the nerve fibre is easy. Mental influences are next added to physical. The will of another is directing the selection and combination of stimuli, and this is done not only with the patient's consent, but even with his willing and hearty co-operation. If I pass into sleep under such conditions, I carry into the somnolent state the understanding involved: I am pre-disposed to listen to the voice of the operator, to submit to his guidance, and to accept his suggestions for direction of action. . If his suggestions are absurd, I shall act absurdly; if they are reasonable, I shall act rationally. The absurdity and the rationality equally originate with him. My activity is within compass of the undertaking with which experiments were begun; and the consequences are in accordance with psychical conditions, without deviation from ordinary laws of mental action. The only thing abnormal for rational life is the relation between the two persons concerned; subordination of personality, reducing it to an instrument; exercise of dominion over another's life such as transfers responsibility largely to the operator. Adding this to the first and simpler phase of hypnotism, we have here in combination two aspects of the abnormal: (1) an artificial sleep with abnormal physiological conditions consequent; (2) an abnormal relation of persons, involving abnormal domination of one over the other, maintained under ordinary conditions of intellectual life, but dependent on intervention of the state of sleep, placing the subject life more completely off guard than could well happen in a waking state. This singular relation of persons is at variance with the conditions of rational life. In this second and much more serious phase of Hypnotism, a transition has been made from a purely physical and altogether temporary result, to *a life effect* altogether novel, and if experiments be persisted in, so that subordination and domination are steadily developed, the result must be pernicious intellectually and morally in the history of *both* lives.

The key to the whole mental possibilities described is in the singular physical state induced. Through the nerve-sleep alone is it possible to bring about such marked subordination and domination as have been described. Without this, everything in mental agency remains normal, strictly in accordance with the conditions of self-regulated life. Inquiry must now be pressed further. The hypnotic state can be induced equally by revolving mirrors, occasioning perplexing optic effects, or by a personal fascination, combining mental influences with physical to the utmost extent favourable for the end. We have specially to inquire how personal influence exercised over others can prove efficient in inducing such a physical result as the nerve-sleep, and thereby gaining an ascendency otherwise unattainable over the mental activity of the patient.

Fascination is a form of dominion by external influence. External impression gains ascendency over the life. An animal seeking its food, and the same animal fascinated by an unfamiliar object, or by the sudden appearance of another animal threatening its safety, present two different phases of life-experience. In the one case, the animal seeks peacefully, in the familiar field of supply, satisfaction for its own need; in the other, the animal is arrested, perplexed, disturbed, and brought into a condition of nerve excitement under which it more easily falls a prey to the other. Something analogous to the latter state appears in the phenomena of hypnotism. Nerve excitability provides the essential condition under which fascination, weariness, and slumber can be caused. Nerve fascination is thus a common danger of life. With man, possibilities and dangers are greatly increased by extension of fascination into the region of mind, where self-regulation is essential for integrity of a responsible existence. It therefore becomes needful to discriminate the several aspects of fascination as these appear in various orders of life.

1. Fascination is possible to animal life, even quite low in the scale of organism. Examples are numerous, suggesting an established phase of subjection, in accordance with the subordination of one order of organism to another. Illustrations readily occur, such as the attraction of some fish by light, which is a simple sensory attraction, appearing in the history of very small marine animals. Fascination is seen in the power of snakes to lure birds into their toils, and in cases when an observer's eye arrests an animal so as to keep it under sensible dominion. It

appears also in the fascination of snakes by men who practise the art. In slighter form, such fascination is mere allurement; in stronger form, it induces nerve-tremor, and is commonly accompanied with cries expressive of fear. In this relation, evidence seems to favour the conclusion that every nerve system is liable to be disturbed and controlled under intensified sensory impression, absorbing nerve energy along a single set of fibres.

2. Fascination under nerve-sensibility may be increased by personal interest in the expected result, and by personal agency towards its production. This is the specialty of intelligent life increasing greatly the potency of fascination. This includes the first stage of hypnotism in human experience, which is never induced without personal contribution towards the result. There must be co-operation in bringing about the end. Under these requirements Moll's position is so far correct, p. 529. Organic conditions are here as in animal life, subordination of nerve-sensibility to external fascination; but mental conditions are superadded, reacting on nerve susceptibility so as to favour the result. The patient experiments on his own sensibilities, with the view of inducing nerve-strain and nerve-sleep. This holds true in all cases where concentration of eye and of thought are maintained deliberately in a single direction, in expectation of sleep. In such a case it is the purpose of the person in all that he does to bring himself under fascination which could not otherwise be produced. It does not clearly appear from evidence that there is danger of abnormal physical excitement under this process, though it seems probable that there are conditions of health in which danger may arise.

3. Fascination through nerve-sensibility may be by concurrent action of the intelligence of operator and patient. Bernheim declares that hypnosis "is a suggestive psychical fascination, and not physical in the least"; but this statement is connected with an explanation that "the magnetiser fixes his eyes upon the subject, who must keep his eyes fixed, and must follow the operator everywhere" (*Sug. Therap.*, p. 16). Intelligent co-operation is here at its height, the operator exerting personal influence to the utmost, and the patient by undivided attention throwing body and mind completely open to his influence. In this case, the operator aims at much more than inducing nerve-sleep. Here the evils of public exhibition become apparent. The professional

"mesmerist," catering for public amusement, is not so foolish as to suppose that an "audience" can be drawn merely to see people go to sleep. He seeks by means of his subjects to fascinate his audience, exercising his love of power, and drawing good pecuniary returns. Mischievous influences here appear from the first, and are readily extended. The occupation becomes fascinating to the operator himself, who is imperceptibly led on to a series of expedients, in which delusion of the sleeper becomes a thing familiar. Full account must be made of all this, in order to reach a just estimate of the phenomena. Discrimination will show that some effects belong essentially to a nerve condition, which can be physically induced; others belong to the ordinary interaction of minds; others are illusions practised on the sleeper, and accepted by him as if he were being honestly dealt with. If these three classes of phenomena be carefully distinguished and contrasted, it will appear that the nerve-sleep itself is the specialty. Delusions practised on sleepers drop down into commonplace, being quite possible with the ordinary sleeper, presenting phenomena analogous to those of our dreaming state, and fitted to awaken curiosity only because we do not ordinarily see men acting their dreams. The relation established between operator and patient makes it easier, when sleep has set in, to practise on the credulity of the sleeper.

We are here naturally led into further study of the power of Suggestion. This power is largely exercised, first to induce the sleep,—this is the favourite method with Liébault,—afterwards to originate and direct action of the sleeper. The sleeper, ceasing to regulate his own action, comes under direction of the suggestions made by the operator. That he should be thus directed involves no disturbance of consciousness. In ordinary sleep, disturbance would be the first effect. Here Imagination and Expectation are largely at work in co-operation with the operator. So powerful does suggestion become, that in some cases a patient often hypnotised will go to sleep at a fixed hour, when the arrangement has been forgotten by his physician. M. Bourneville records such a case (*British Medical Journal*, 1881, vol. i. p. 1010; v. *Felkin's Hypnotism*, p. 17). The guidance of the operator is so fully accepted, that there is unbroken continuity of consciousness when suggestions are continued during sleep. On this account, the phenomena of the sleeping state are unusual and quite unexpected. Results physical and mental are attained which could not otherwise be secured. These are not, strictly speaking, "natural," but abnormal; and if frequently reproduced and continued for a considerable time, there is reason to expect that they will prove physically exhausting. Stimulation of activity in sleep, with high excitement, soon carries physical activity beyond the natural limits of endurance. Risk of this must be incidental to all experiments practised under use of hypnotism in public exhibitions.

The natural conditions of life are disturbed when activity is suggested during slumber. Sleep is thus made to be an intermediate stage towards abnormal results. This sleep itself is, besides, to be accounted a specialty, often involving serious physiological disturbance. Beyond this, sleep is only a single condition in the midst of a complex group of causes, all of which co-operate in producing abnormal effects.

When these three phases of fascination have been distinguished, it will appear that the chief dangers of hypnotism are connected with the last. This involves experiment possible only in human life; and it leads on to dangers belonging specially to moral life. A nerve-sleep seems possible to any organism under experience of the simplest form of fascination. When fascination of the eye is experienced by animals, they quickly avert the eye, as if sensible of the need for ending the influence. If man, in full exercise of his intelligent purpose, lay himself open to all the possibilities of fascination—physical, intellectual, and emotional—there is danger connected with all three phases of activity. This will appear from estimate of results.

Intellectual and emotional accompaniments need to be registered. 1. Earlier effects involve a degree of mental concern, causing nerve-tremor, often aggravated by apprehension of possible yet undefined consequences. 2. This fear is abated by the allurements of personal interest. Increase of interest is promoted by agreeable experience as sleep is being induced. 3. Fascination gains in proportion to loss of observational command, and to continuance of suggestion by the operator. 4. When sleep has been established, suggestion *ab extra* rules the subordinated life. The sleeper is now largely a tool in the hands of the operator, instead of an unrestrained voluntary agent. He himself is personally responsible for being so situated. The operator is legally and morally responsible for his suggestions and for their consequences, these being entirely determined by him. Mutual responsibility is seriously increased when it is apparent that subordination of the one life to the other is being extended by continued co-operation. When fascination is in the ascendant, suggestion *ab extra* is master of the life to an extent to which no human life should be mastered. There is nothing absurd, grotesque, or foolish in the undisturbed experience of the sleeper. Left to himself, his experience would be one of quiet rest. But the operator may suggest unnatural activity, and may encourage motives which would be rejected in the waking state.

We have finally to consider what restrictions on activity, and what larger possibilities, physical and mental, have been disclosed by the phenomena of hypnotism taken in their widest range.

1. Nerve sensibility implies liability to nerve strain, consequent on continued excitation of a single nerve-fibre or set of fibres, and continuance of such strain leads on to an abnormal nerve-sleep or lethargy, involving deterioration of nerve control.

Such concentrated and strained use of a single nerve-fibre, or of a correlated set of such fibres, is alien to the normal conditions of sensori-motor activity. Ever varying exercise in view of changing relations to the external is the common law of life-action. Change of nerve action is a natural condition favourable to functional activity of the whole nerve system, just as winking of the eyelids during continued use of the organs of vision seems needful as a break on the continuity. The concentration resorted to in hypnotism is not such as belongs to skilled work, giving continual change of result by exercise of art. It is a concentration which not only shuts off variety, but deliberately aims at monotony as a condition favourable for inducing sleep. Hence Braid insisted that the patient "keep the eyes steadily fixed on the object and the mind riveted on the idea of that one object." So essential did he hold this to be, that he attributed numerous failures to the neglect of it.

2. Concentrated and strained nerve excitation, habitually resorted to for inducing nerve-sleep, develops an abnormal nerve tendency increasing the facility with which such sleep is established.

Notwithstanding any "derangement of the state of the cerebro-spinal centres" which may ensue, this action of the law of habit is clearly proved. This result is purely physical.

3. In nerve-sleep, as in ordinary slumber, intellectual activity continues possible, in accordance with the ordinary laws of association in consciousness.

The intelligent life adapts itself to changed physical conditions. In course of this adaptation, new associations are established, and are turned to use as in ordinary life. The sleeper becomes familiarised with his reception of suggestions, just as in ordinary life we become familiar with the voice of a companion, or with occupations to which we are strange at first. Everything here is in accordance with normal action of mind.

4. In absence of personal determination to action while asleep, suggestion supplied by the operator is interpreted and applied by the sleeper, as if he were directing his conduct under ordinary conditions.

This is the only adequate interpretation of the phenomena. Evidence is clearly against either a mechanical action of suggestion, or causation of the activity of the sleeper by immediate influence of the will of the operator. The sleeper hears, interprets, accepts, and acts upon the suggestion made, exactly as he does in the waking state under persuasion of a companion. It is an altogether inaccurate statement of the occurrence when it is said to be "the implanting of the will of one person on the brain of another." It is the action of the will of one person formulating and communicating suggestion so as to secure co-operation of the will of another by direction of his own action.

5. Accepted suggestions gradually establish associations in consciousness which come to be acted upon as fixed conditions of life, being sustained by renewed experience of their guidance in the nerve-sleep.

It is in accordance with fixed laws of association that physical and mental experiences should be combined in the life. In hypnotism sleep-experience and suggestive-experience are being harnessed together, and trained to move together in daily work. "Suggestive associations" are naturally resumed, as "sleep-associations" are restored. "It appears quite evident that whatever images, or mental emotions, or thoughts have been excited in the mind during nervous sleep, are generally liable to recur, or be renovated and manifested, when the patient is again placed under similar circumstances" (Braid, Pref. xvi). All this is in accordance with ordinary laws of memory.

6. Subjection of the sleeper, and domination of the operator advance together.

This acquiescence of the mind of the sleeper is only in accordance with experience in ordinary life, when the sway of a companion is being fixed. Compliance is easy; deliverance requires rebellion. To acquiesce in such subjection as the nerve-sleep favours, is a dire calamity for the life. If we could imagine this dominion of the operator *completely* established, the subject life would produce nothing. Intellect would be reduced to an instrument receiving and transmitting to its own organism, and through it to the external world, the suggestions of another. The end must be slavery, intellectual and moral. Even under a modified and merely temporary subjection the sleeper is, during fixed periods of his life, dependent on the character of the operator for what is done, a dependence which should not be matter of agreement.

These are the essential lines on which is to be found interpretation of the phenomena of hypnotism. The results as bearing on the relations of Mind and Brain are the reverse of those commonly supposed. They offer special testimony to the superiority of mind in the government of physical activity. Even in sleep, when the suggestion of another is accepted unquestioningly, intelligent interpretation and voluntary application of the suggestion are essential conditions, in order that the operator may illustrate before his audience. The physical has been thrown into subordination, under abnormal and unexpected conditions, and mind is seen operating in harmony with its familiar laws for control of organism. The specialty disclosed is the liability of the nerve system to a paralysing fascination, inducing nerve torpor. Such torpor closes off ordinary observation, yet is compatible with a lucid action of mind under the leading of suggestion, unquestioningly accepted on account of the understanding established.

So far as the physical condition is concerned, sleep is induced under strain of the nerve system, or under suggestion of phases of sensibility attendant on exhaustion of nerve energy. The hypnotic state is an artificially induced nerve prostration. Such a physical state ought not to be sought for its own sake,—ought to be shunned, as we naturally avoid everything ennervating. Abatement or cure of physical disorder seems the only warrant for resort to such an artificial sleep.

The phenomena of Memory in the hypnotic state, further illustrate the relations of mind and body. In a lighter somnambulistic state there is a partial recollection of what has occurred: in a deeper somnambulism there is no recollection. Memory is thus shown to have its physical and its intellectual sides. With abatement of nerve sensibility, and consequent diminished observation, there is restricted action of memory. Active memory implies concentrated attention. Return to the normal conditions of life breaks the relation with hypnotic experience, and we lose our hold upon such experience, as we lose hold of our dreams. Return to the hypnotic state restores recollection of the events which had occurred previously in the nerve-sleep.

As to the mental phenomena, there is evidence of the acceptance unquestioningly of most suggestions made by the operator, but there is no evidence of modification of the powers of mind, or of the laws of mental action. Any peculiarity in mental condition is consequent merely on detachment from the ordinary conditions of sensory observation. Mental experience becomes analogous to that in the dreams of ordinary sleep. There is no illumination of mind making a man intellectually higher (Bernheim, *Sug. Ther.*, p. 60); no change of temperament; only a special facility in accepting suggestions, clearness of interpretation of their meaning, firmer belief in their possibility, and alacrity in putting them into execution. Beyond this, there lies nothing but application of the ordinary laws of association.

The value of hypnotic experiments here appears in the light thrown on the relations of body and mind. Hypnotism shows that forms of physical sensibility may be mentally induced; and that motor powers may be worked automatically, provided the associated mental states can be induced by suggestion. The phenomena of hypnotism harmonise with illustrations of automatic action in the history of those who have suffered such injury of brain as to induce a measure of paralysis. The case given by Dr. Mesnet, an eminent French physician, quoted at length by Professor Huxley (*Science and Culture*, pp. 223-231), affords an example which we give here, as exceedingly suggestive in the light of hypnotic results. A summary of the leading particulars will suffice. A sergeant of the French army, F——, was wounded during the battle of Bazeilles, by a ball which fractured his left parietal bone.

His right side became paralysed, and remained in this condition for a year. After this, power in the right side returned, although a slight sense of weakness continued. Periodical disturbances of the functions of the brain appeared, lasting from fifteen to thirty hours, and occurring at intervals of from fifteen to thirty days. In ordinary health he performed satisfactorily the duties of hospital attendant. The abnormal affection begins with uneasiness, and sense of weight about the forehead, but without convulsions or cries. His movements remain free and his expression calm, except for a contraction of the brow, an incessant movement of the eye-balls, and a chewing motion of the jaws. "The eyes are wide open, and their pupils dilated. If the man happens to be in a place to which he is accustomed, he walks about as usual; but if he is in a new place, or if obstacles are intentionally placed in his way, he stumbles gently against them, stops, and then, feeling over the objects with his hands, passes on one side of them. He offers no resistance to any change of direction which may be impressed upon him, or to the forcible acceleration or retardation of his movements. He eats, drinks, smokes, walks about, dresses and undresses himself, rises and goes to bed at the accustomed hours. Nevertheless, pins may be run into his body, or strong electric shocks sent through it, without causing the least indication of pain; no odorous substance, pleasant or unpleasant, makes the least impression; he eats and drinks with avidity whatever is offered, and takes asafœtida, or vinegar, or quinine, as readily as water; no noise affects him; and light influences him only under certain conditions. Dr. Mesnet remarks that the sense of touch alone seems to persist, and indeed to be more acute and delicate than in the normal state; and it is by means of the nerves of touch, almost exclusively, that his organism is brought into relation with the external world" (*Science and Culture*, p. 225). Here is a case in which ordinary observation is reduced to a minimum, in a manner analogous to the condition of nerve-sleep. Under the abnormal limitations described, we see what organism can accomplish by means of previously established forms of cerebral co-ordination. An incident described by Dr. Mesnet will afford material for suggestion. "The sergeant when walking in the garden under the large trees had dropped his stick. Some one placed it in his hand. He felt it, advanced by rapid strides, his hand resting on the bent handle of his cane—he became attentive—seemed to listen—and suddenly called 'Henry! There they are. They are at least twenty to our two. We shall conquer them!' Then, putting his hand behind his back as if to take a cartridge, he made the movement as if loading his rifle, and lay down flat in the grass, his head hidden by a tree, in the posture of a sharpshooter, and there, with the rifle at his shoulder, he followed all the movements of the enemy, whom he thought he saw at a short distance." The mere feeling of the cane, placed in his hand as if it were his rifle, started into activity all those motor centres which military drill had associated. This is in striking accordance with the suggested action of the person hypnotised. It is obvious that sensori-motor activity accomplishes, in human life, as in animal, a large amount of effort commonly assigned to mind. Much of the muscular activity, possible at first only by intelligent observation and by voluntarily directed effort, can by acquired facility be afterwards performed by co-ordination of cerebral appliances, without intervention of intelligence. Motor centres become associated and predisposed to associated action, so that the awakening of the associations, even by a single form of sensibility, will prove sufficient to provide for performance of a complicated round of actions.

Two additional facts in the conduct of the sergeant are helpful in the study of hypnotism. He began humming a tune, "went to his room, dressed himself carefully, and took up some parts of a periodical novel, which lay on his bed, as if he were trying to find something." Dr. Mesnet rolled up one of the periodicals, and placed it in his hand; with this he went out, and coming to a stand in front of a window through which the sun was shining brightly, he "sang with perfect execution three songs, one after the other." On another occasion he took a slip of note-paper containing several sheets and began to write. "After he had written a line or two, this sheet was suddenly drawn away. There was a slight expression of surprise, but he continued his letter on the second sheet exactly as if it had been the first. This operation was repeated five times, so that the fifth sheet contained nothing but the writer's signature at the bottom of the page. Nevertheless, when the signature was finished, his eyes turned to the top of the blank sheet, and he went through the form of reading over what he had written, a movement of the lips accompanying each word; moreover, with his pen he put in such corrections as were needed, in that part of the blank page which corresponded with the position of the words which required correction in the sheets which had been taken away. If the five sheets had been transparent, therefore, they would, when superposed, have formed a properly written and corrected letter."

This case affords striking analogy with hypnotic experience, in absence of pain under prick of a needle, in lack of sensory experience as to taste, and in readiness to act upon suggestions made. An abnormal nerve condition may at once restrict activity in some parts, and provide for even higher than normal action in other parts of the nerve system. All this has a strong resemblance to the phenomena of hypnotism. Under whatever restrictions consequent on a disturbed state of the nerve centres, the mind acts in accordance with mental and physical associations previously established. Sensory impression, or verbal suggestion, may suffice to set in operation co-ordinated physical processes, leaving the agent unaware of what is being done by him. Much of the activity executed in this state is automatic; all that is voluntary depends on intelligent interpretation of suggestions audibly communicated.

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